TEMPORAL AND SPACIAL VARIABILITY OF SOUND PROPAGATION IN THE OCEAN.

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THESIS

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MAR 1971

Temporal and Spacial Variability of Sound

Propagation in the Ocean

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
March 1971

ABSTRACT

The purpose of this study is to investigate the influence of non-environmental and small scale environmental acoustic factors on the variation of transmission loss within areas of the ocean which exhibit homogeniety of large scale environmental factors. The method employed was to identify the influencing and non-influencing factors, pool over the non-influencing factors if they existed, and investigate the nature and magnitude of the effect of the influencing factors on the variation of transmission loss.

The results generally indicated that source/receiver depth, the mixed layer, geographic location, and transmitting range and frequency significantly influenced the variation of transmission loss.

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SYMBOLS AND ABBREVIATIONS

Av	average
BT	bathythermographic
C( )	autocovariance function
Cov	covariance
Fath	fathoms
Freq	frequency
Ft	feet
db	decibel
KC	kilocycle
Kyds	kiloyards
Rng	range
Trans	transmitting
Var	variance
XMT	transmitter (source)
Δ	change in
μ	mean

I. INTRODUCTION

In recent years, with the advent of more sophisticated SONAR systems, there has been an increasing emphasis placed on the study of the acoustic properties of the ocean. To be able to predict the capabilities of a particular SONAR system, whether it be passive or active in nature, requires a complete understanding of the effect of the local acoustic environment on the transmission of sound through the water. Both theoretical and observational techniques have been utilized in an effort to determine the environmental and non-environmental factors which effect the transmission of sound and then to characterize this transmission as a function of those factors.

One study of this nature was the AMOS project performed under the sponsorship of the U. S. Navy in the early 1950's (ref. 5). In this study, the behavior of sound transmission was measured along with local environmental characteristics over a wide range of environmental and non-environmental factors. On the basis of these observations, transmission loss prediction equations were developed as a function of certain factors such as source and receiver depths, range of transmission, mixed layer depth, etc. However, these equations are quite insensitive to small scale environmental characteristics such as inhomogenieties in the thermal structure and irregularities at the air-sea and sea-earth

interfaces. As a consequence, transmission losses observed operationally are often quite variable with respect to the predicted losses on the basis of these equations.

This study is an extension of the work performed in the AMOS experiment in that it investigates the nature of the small scale environmental factors which influence the observed temporal and spacial variability in acoustic propogation. The characterization of this variability as a function of these factors will be useful in a variety of applications. Some examples are:

1) Establishing some design specifications for new SONAR systems.
2) Establishing SONAR detection probabilities for shipboard use.
3) Simulation of environmental conditions for use with detection simulation models.

II. A MODEL OF THE ACOUSTIC ENVIRONMENT

Within sufficiently small areas of the ocean, the large scale environmental factors (i.e., thermal, density and salinity profiles) may be considered spacially consistent. Such areas may also be considered temporally consistent for short durations of time. Since general acoustic behavior is a function of these large scale environmental conditions, such an area may be considered acoustically homogeneous. This, however, does not imply that the acoustic behavior is independent of small scale temporal and spacial inhomogeneities within this large scale environmental structure. Hence, the environment may be characterized as a generally homogeneous medium which dictates the large scale acoustic behavior, but one having small temporal and spacial inhomogenieties which cause variations in acoustic behavior.

On the basis of this characterization, sound transmission loss may be modeled as a stationary stochastic process whose mean is a function of the large scale environmental factors, and whose autocovariance function is a function of the small scale environmental factors. Denote this process, where $X(t)$ describes the transmission loss, by $X(t); t \geq 0$. It is convenient to characterize this process by its mean

$$\mu = E(X(t))$$

and by its autocovariance function

$$C(\Delta t) = E((X(t) - \mu)(X(t + \Delta t) - \mu)).$$

It is then possible to study the nature of the variability which occurs in transmission loss due to small scale environmental aspects by considering the environmental and non-environmental factors which effect $C(\Delta t)$.

Two particular parameters which characterize this variability are $C(0)$, the variance of the process and hence the amount of variability that would be experienced within an acoustically homogeneous region for a given source and receiver depths, and Δt^*, the minimum value of Δt for which $C(\Delta t) = 0$, which represents the shortest time interval between independent observations. These two parameters, $C(0)$ and Δt^*, may be determined for a given process if that process is observed either continually or at discrete increments of time. Then by observing such processes under varying acoustic conditions (such as thermal structure, geographic location, time of day and year, etc.) it should be possible to determine how $C(0)$ and Δt^* vary as a function of the acoustic environment.

However, it is not necessary to observe the entire process to determine $C(0)$ and Δt^*. Specifically, if the process of transmission loss is observed at two points in time separated by Δt and these pairs of points are observed many times at varying values of Δt for the same process, or equivalently from processes with the same

autocovariance functions, then this information may be used to estimate $C(\Delta t)$ and hence, $C(0)$ and Δt^*. This may be accomplished in the following way:

Let

$$Y(\Delta t) = X(t) - X(t+\Delta t)$$

represent the difference between two measurements in transmission loss taken in the same location but separated in time by Δt.

Then

$$E(Y(\Delta t)) = 0$$

and

$$\begin{aligned} Var(Y(\Delta t)) &= E(Y(\Delta t)^2) \\ &= Var\ (X(t)) + Var\ (X(t+\Delta t)) - \\ &\quad 2C\ (\Delta t) \\ &= 2\ (C(0) - C(\Delta t)) \end{aligned}$$

The value of $Var(Y(\Delta t))$ may then be determined for a given Δt from the observations of $Y(\Delta t)$ corresponding to pairs of observations of transmission loss with the same autocovariance functions, $C(\Delta t)$. $C(0)$ may then be represented by

$$C(0) = Var(Y(\Delta t^*))/2$$

where $Var(Y(\Delta t^*))$ is the value of $Var(Y(\Delta t))$ when $C(\Delta t)$ approaches zero or when $Var(Y(\Delta t))$ no longer increases with Δt. Δt^* is then the time interval where this first occurs.

If pairs of observations of transmission loss cannot be obtained from the same process, then it is necessary to pool information from different processes with the same autocovariance function. The problem here arises in specifying the range of conditions under which this may be done. The approach taken in this study was to characterize the local acoustic environment by its thermal structure where it was hypothesized that environments with similar thermal structures will produce processes with similar if not identical autocovariance functions. This assumes that other variables such as transmitter and receiver depths and transmission ranges will remain constant.

III. NATURE OF THE DATA

The data utilized in this report was made available by the U. S. Underwater Sound Laboratory, New London, Connecticut, and reflects the raw data collected during the Acoustic, Meteorological and Oceanographic Survey (AMOS) conducted from June, 1949, through April, 1953. There were nine cruises staged during these four years which covered the North Atlantic, the Norwegian Sea, and to a lesser extent, the Mediterranean Sea.

Two ships were employed during each cruise where one acted as the transmitting platform and the other as the receiving platform. Each of the cruises was divided into several widely spaced stations which served as the focal points for data measurement and collection. Within each station, the acoustic data was collected at several transmission ranges between 800 and 30,000 yards. At each transmission range the transmission loss measurements were observed for four transmitting frequencies at various source/receiver depth combinations. The transducer depths varied from 20 to 500 feet. The specific data recorded was transmission loss, in decibels (db), as a function of source/receiver depths and range between ships. Table X lists the information that was recorded.

Accuracy of the data becomes particularly important in consideration of the accuracy of any results obtained

through the use of that data. The following list gives an approximate measure of the accuracy of the AMOS data:

1) time - to the nearest minute
2) range - to the nearest 5 yards
3) transducer depths - to the nearest foot
4) water depth - to the nearest 10 fathoms
5) latitude and longitude - to the nearest minute although it is possible that the two ships may have drifted as much as a mile or two from the recorded position
6) BT pattern code - reflects the gross thermal conditions closest to the time that the data was recorded.

IV. ASSUMPTIONS

As indicated in the introduction, this paper deals with determining the variation of transmission loss by examining the variation of the change in transmission loss as a function of the elapsed time between a pair of observations. Ideally it would be best if this change in decibel loss could be measured from a pair of observations with identical source and identical receiver depths, and with the same horizontal transmitting range, but separated by an interval of time, Δt. Although data of this nature was not available from the AMOS experiment, pairs of observations of db loss were obtained having the following characteristics:

1) One of the observed pair measured the transmission loss of a signal generated at depth d_1 and received at depth d_2 while the other measured transmission loss of a signal generated at depth d_2 and received at depth d_1.
2) Identical transmitting ranges between the source and receiving ships was not always available within a pair of observations.

Figures (1) and (2) depict the nature of an ideal pair of observations and that of the available data.

The fact that the change in transmission loss was measured using transmission paths that 'crossed' instead of

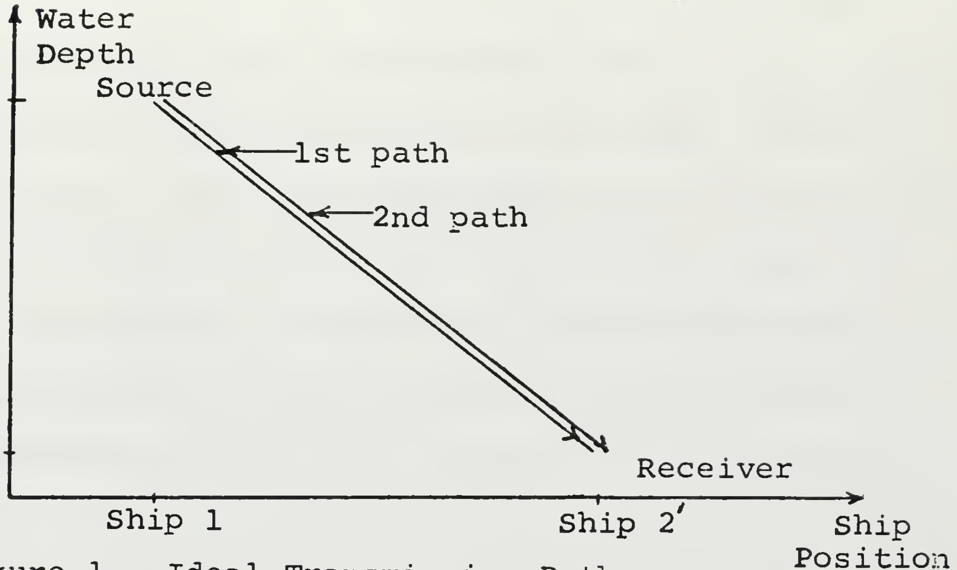

Figure 1. Ideal Transmission Paths

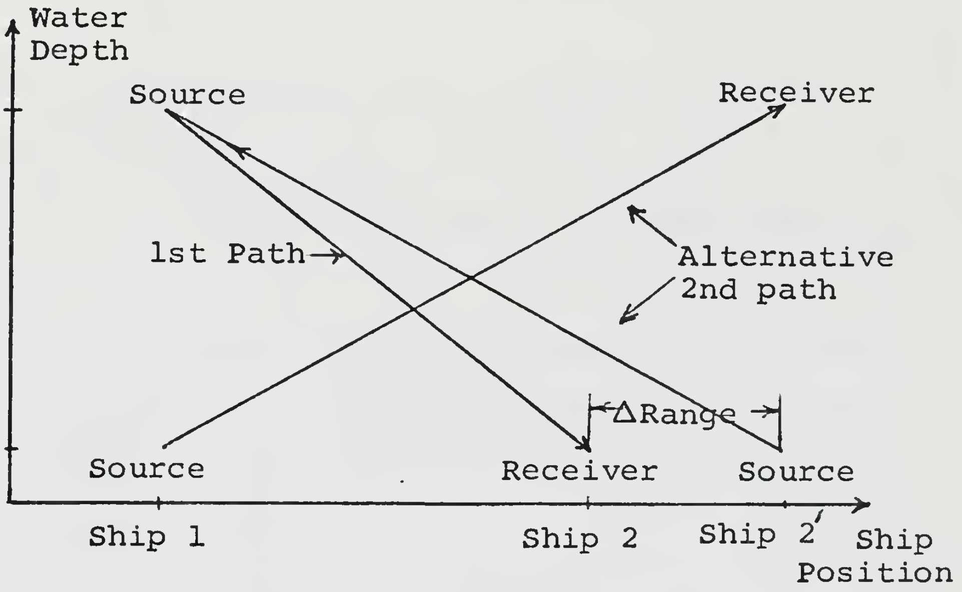

Figure 2. Available Transmission Paths

being 'parallel' was considered not to be a serious departure from the ideal conditions (refs. 3 and 5). This follows from the assumption of a generally constant horizontal thermal environment, and therefore an acoustically

homogeneous environment over the range of operation of the two ships on a given station, and theoretical considerations which postulate that transmission loss over the same path from different directions will be the same. It is foreseen, however, that this approximation to the ideal case of parallel transmission paths will increase the observed $Var(Y(\Delta t))$ for small Δt due to a contribution caused by small scale spacial variability, and may also cause a slight underestimation of Δt^*. However, the estimation of $C(0)$, the measure of total variation experienced within a generally homogeneous acoustic environment, will not be effected.

The second data characteristic of range differences between the two observations in a pair was treated in the following manner. The observed change in transmission loss was adjusted for the effect of this range differential on the basis of a piecewise linear approximation of transmission loss vs. horizontal transmission range. This linear approximation seemed reasonable in the interest of keeping the range adjustment computation simple and yet maintaining sufficient accuracy. Plotting transmission loss vs. transmission range for each source/receiver depth combination at each station revealed that the resulting relationships exhibited the same general shape and that these relationships could be approximated by two linear segments with the break point at 5,000 yards.

As the slopes of these two linear segments are a function of the local environmental conditions, and thus varied from station to station, it was necessary to estimate the slope for each segment at each station for each source/receiver depth combination. This was done on the basis of the transmission loss observed at the various ranges occupied on a given station. Then the change in transmission loss observed at a particular station and source/receiver depth was adjusted using the corresponding slope of transmission loss vs. transmission range in the following manner:

$$\Delta db_{adjusted} = \Delta db_{observed} - b \times \Delta \text{ range}$$

where Δ db represents the change in transmission loss, b is the slope of the corresponding linear segment, and Δ range is the range differential within a pair of observations.

In some cases insufficient data was available to estimate the slope of one or both segments at a given station and source/receiver depth combination. In such cases the corresponding adjustments were made on the basis of a slope which was typical of other stations on the same and other cruises. Table I depicts a representative cross-section of the average slopes from the available data. Listed below is a summary of the typical slope values selected for use within this study where sufficient data was not available for slope calculations.

Range Interval	Slope Value	Applicable Cruises
Above 5,000 yards	.0015	5, 7, 8, 9, 10, 11, 12
Below 5,000 yards	.0045	7, 8, 9, 10, 12
	.0100	11
	.0280	5

Admittedly this adjustment procedure is subject to error. In particular, the error incurred by using a linear approximation in the first place, and secondly in the estimation of the slope of the transmission loss vs. transmission range relationship. It was felt, however, that in general the total error inherent in this procedure could be restricted to at most $\pm.5$db by making no adjustments with range differentials within pairs of observations of more than 500 yards. Errors of such magnitude were considered acceptable in light of the original accuracy in measuring transmission loss in the AMOS experiment. In actual practice, this error was further limited by the fact that few adjustments in change in transmission loss were made for range differentials greater than 250 yards.

V. RESULTS

A. METHODOLOGY OF INVESTIGATION

The purpose of this research is to investigate the nature and magnitude of the variability in sound propogation loss as characterized by $C(\Delta t)$ by investigating the variability in the change in transmission loss as a function of time between observations. The calculation of transmission loss as a function of time, denoted by $Y(\Delta t)$, was obtained from the AMOS data in all instances where a pair of transmission loss observations were taken under the following conditions:

1) The compared observations were taken at the same station.
2) The range differential between observations was no greater than 500 yards.
3) The source depth of one transmission equalled the receiver depth of the other, and vice-versa, thus resulting in a comparison of observations with similar but not identical transmission paths.

These calculations of change in transmission loss over common paths were indexed by the following environmental and non-environmental factors:

1) Source and receiver depths
2) Transmission range

3) Transmitting frequency

4) Water depth

5) Mixed layer depth

6) Geographical location

7) Time interval between corresponding observations

8) Time of day and year

The investigation of variability in sound transmission was confined to the influence of the above factors. To determine this influence using the available data, it was necessary to pool data collected under varying environmental conditions. Such pooling is only applicable, however, over a range of environmental conditions where the acoustic variability is characterized by a common autocovariance function. Hence, it is necessary to determine how to identify the range of conditions which lead to a common autocovariance function. In particular, it is necessary to determine which factors, both environmental and non-environmental, influence the nature and magnitude of the variation of propogation loss in the ocean and then pool over the entire range of those factors which did not so influence this variation.

The procedure followed was to plot $Var(Y(\Delta t))$ vs. Δt using the entire sample set of data and thus representing the entire range of environmental and non-environmental conditions encountered. This entire sample of data was

then subdivided into sub-samples on the basis of the source/receiver depth combination and $\mathrm{Var}(Y(\Delta t))$ vs. Δt was plotted for each sub-sample. By this procedure, it was determined that the nature and magnitude of $\mathrm{Var}(Y(\Delta t))$ depended upon the sub-sample (i.e., source/receiver depth combination) considered. Hence, it was deemed inappropriate to pool the data over source/receiver depth combinations when considering the influence of other factors on $\mathrm{Var}(Y(\Delta t))$.

To determine if the thermal structure influenced $\mathrm{Var}(Y(\Delta t))$, each of the above sub-samples was further subdivided on the basis of the location of the receiver and source depths with respect to mixed layer depth. On the basis of this subdivision, it was determined that the positioning of the source and the receiver with respect to the mixed layer depth also influenced the nature and magnitude of $\mathrm{Var}(Y(\Delta t))$.

The influence of geography and transmission range were also investigated in the same manner by subdividing the sample data on the basis of these factors. As it was necessary to keep the respective sub-samples as large as possible when considering a given factor, it was found that certain sub-samples should not be further subdivided. Such was the case for some of the less representative source/receiver depths.

By proceeding in this manner, it was determined that, of the factors being considered, those which were judged to have a significant influence on the nature and magnitude of $Var(Y(\Delta t))$ were: 1) source/receiver depth, 2) location of the source and receiver with respect to the mixed layer, 3) geographic location, and 4) transmission range. It was also determined that the transmitting frequency had a marked effect on the magnitude of $Var(Y(\Delta t))$. The actual nature of these influences will be discussed later.

It should be emphasized that $Var(Y(\Delta t))$ is twice the value of $C(0)$ and thus $Var(Y(t))$, the variation of transmission loss.

B. LIMITATIONS EFFECTING RESULTS

There are two considerations which tended to limit the results of this paper. The first was that the amount of data available to estimate $Var(Y(\Delta t))$ as a function of Δt was limited in some of the finer subsamples defined in the previous section. Hence it was found necessary, in order to obtain a reasonably precise estimate of $Var(Y(\Delta t))$, to pool the available data into several consecutive 15 minute intervals.

The second consideration was that, due to physical limitations imposed on observation of the data during the AMOS experiment for a given source/receiver depth combination, the majority of the available data was restricted to

at most three 15 minute intervals. These three intervals, however, were not necessarily the same for each source/ receiver depth combination, but tended to the small values of Δt for closely spaced source and receiver depths and to the large values for widely spaced source and receiver depths.

The implication of these data limitations was that Δt^* could not be determined with a precision greater than 15 minutes. However, this was thought not to be a serious limitation. A possibly more serious limitation is that, because of the dispersion of the data as a function of Δt, the value of $\mathrm{Var}(Y(\Delta t))$ cannot be estimated with equal precision from interval-to-interval and from depth combination-to-depth combination. In particular, for a given source/receiver depth combination, there may be little or no data available for the interval when $\mathrm{Var}(Y(\Delta t))$ reaches its maximum value. In general it is felt that this did not happen, although there is no way of verifying this at the present time.

C. FINDINGS

1. Distribution of Transmission Loss

As suggested in the introduction, knowledge of the nature of the variability in transmission loss may be utilized to produce a realistic simulation of the acoustic

environment. To do this it is necessary to know not only the magnitude of this variation, but also its distribution.

The typical assumption that this distribution is normal is evaluated on the basis of the available data for a representative cross-section of subsamples of the data. The basis for this examination is the Kolomogorov-Smirnov one-sample goodness-of-fit test (ref. 2). Table II gives the results for all subsamples considered, and the range of conditions which define the tested subsample. Also given are D_{max}, the maximum absolute difference between sample cumulative distribution and a normal cumulative distribution with mean zero and sample variance of the subsample. The critical value has the same connotation usually associated with hypothesis testing and represents the level of significance at which the null hypothesis of no departure from normality would be rejected.

The general conclusion on the basis of these results is that the normal distribution is an adequate approximation for the distribution of transmission loss.

2. <u>Factors Effecting the Variation of Transmission Loss</u>

a. Source/Receiver Depth

The first attempt at determining which environmental and non-environmental factors influenced the nature and magnitude of $Var(Y(\Delta t))$ was in the area of source/receiver depths. The available data was subdivided on the basis of several source/receiver depth combinations.

The results thus obtained proved to be quite noisy and it was decided to employ the same procedure for cruise 10 only since the thermal structure appeared more consistent on that cruise. The results of this procedure seemed satisfactory for exposition purposes and are summarized in Table III.

It is interesting to note that not only does $Var(Y(\Delta t))$ increase as time increases, but that this variation also increases with an increasing depth differential between source and receiver. Also noted was that $Var(Y(\Delta t))$ tended to decrease as the source depth increased. The latter is probably attributable to surface effects.

b. Mixed Layer Depth

Once it had been decided that the different source/receiver depth combinations each influenced $Var(Y(\Delta t))$ differently, the next step was to consider the position of the source and receiver with respect to the depth of the mixed layer. This was accomplished by further subdividing the data into two subsamples on the basis of whether both the source and receiver were in the mixed layer, or at least one was below the mixed layer. The rational behind this subdivision was to determine if the variability of transmission loss was different when the transmission path was above the thermocline or across the thermocline.

Table IV shows the results of this investigation and clearly indicates that $Var(Y(\Delta t))$ is

considerably less within the mixed layer. The differences observed may in part be a function the existence of internal waves.

c. Geographic Location

Geographic location was found to have a significant effect on the variation of transmission loss. To facilitate investigating the nature of this effect, areas were selected which were thought to have approximately the same large scale environmental characteristics. The areas chosen were:

1) 50-80 N, all longitudes
2) 0-50 N, 0-60 W
3) 0-50 N, 60-90 W

Four source/receiver depth combinations were then picked which would ensure that sufficient pairs of observations would be available within each of these depth combinations. The subsamples have been further subdivided according to the position of the source and receiver with respect to the mixed layer. Table V depicts $Var(Y(\Delta t))$ for the geographic areas and the four depth combinations selected. The variation of transmission loss for each combination pooled over all latitudes and longitudes has also been included in the table for comparative purposes.

As indicated by the entries in Table V, there does not appear to be any consistently predictable direction or magnitude associated with $Var(Y(\Delta t))$ across the

three geographic locations. However, the variations do seem to change significantly both from the "all latitude-longitude" case, and across geographic areas. This would seem to substantiate the hypothesis that geographic location is a significant factor effecting $Var(Y(\Delta t))$. The data in Table VI, which breaks the variation of transmission loss down into 15 minute intervals, also appears to substantiate this contention.

d. Transmitting Frequency

The effect of transmitting frequency on $Var(Y(\Delta t))$ is apparent; increasing the frequency increased the magnitude of the variation. Two frequencies were selected to investigate this hypothesis, 8 and 25 KC. Table VII is a summary of $Var(Y(\Delta t))$ for both frequencies for several source/receiver depth-geographic location-mixed layer depth combinations. The increase in $Var(Y(\Delta t))$ is evident.

e. Transmission Range

The transmission range appeared to have a significant effect on $Var(Y(\Delta t))$. Table VIII shows this variation for range intervals of 0-10 Kyds and 10-30 Kyds for pairs of observations at the 8 KC transmitting frequency pooled appropriately according to source/receiver depth, geographic location and mixed layer depth. An examination of this data suggests that $Var(Y(\Delta t))$ was generally lower for greater ranges and that estimates of variation

in the mixed layer was less consistent than for those transmissions crossing the layer.

3. Investigation of Large Values of Change in Transmission Loss

Because of the limited amount of data in some subsamples considered, the estimator of $Var(Y(\Delta t))$ was quite sensitive to a not uncommon occurrence of disproportionately large values of the change in transmission loss. In an attempt to determine the nature of the circumstances which lead to such observations, a sample of observed changes in transmission loss whose absolute value exceeded 9db were examined as to the conditions under which they were observed. This sample consisted of all instances for 20/100, 50/100, 50/250 and 100/500 foot source/receiver depths at 8 KC transmitting frequency, and 20/100 and 100/500 foot source/receiver depths at 25 KC transmitting frequency. Table IX is a summary of these data.

On examination of these data it is concluded that, except for a marked effect of frequency and a suggested effect of time of day, no common single or set of circumstances is related to the large changes in transmission loss. This does not mean that such a set of circumstances does not exist, but that it is not apparent what such a set would be based on in consideration of these data and this specific set of indices.

This latter point has lead to the consideration that there may be a more appropriate set of indices with which a measured change in transmission loss may be classified. The nature of such a set of indices is suggested by considering the results of the present study. That is, that $Var(Y(\Delta t))$ varied with the proximity of the source or the receiver to the surface, the depth differential between the source and receiver, the relationship of the source and receiver to the mixed layer, geographic location, etc. These factors are exactly those which influence the mode of transmission of a signal in the general transmission loss equations obtained in the AMOS study (ref. 5).

In that study it was determined that transmission loss depended on the mode of transmission. In particular on whether transmission was by

1) Direct path
2) Single surface bounce
3) Multiple surface bounce
4) Leakage by diffraction or scattering
5) Depressed sound channel
6) Bottom bounce

On the basis of the results of the present study, it appears that the nature and magnitude of the variability in transmission loss might also vary with transmission mode. Further, it is envisioned that subdividing the available

data on the basis of transmission mode will yield a more uniform distribution of Δt for a given subsample and, in general, increase the amount of data available for the estimation of $Var(Y(\Delta t))$ for any particular interval of Δt.

VI. CONCLUSIONS AND RECOMMENDATIONS

The aim of this study was to determine the environmental and non-environmental factors which influence the nature and magnitude of the variability in transmission loss, and then to characterize this variability as a function of these influencing factors.

On the basis of this study it was found that the variation in transmission loss was influenced by the depth of the source and receiver of the transmitted signal, the relationship of the source and receiver depths with the mixed layer depth, geographical location, and transmission range.

The nature of this influence was that the magnitude of variability increased with increasing transmitting frequency, with increasing depth differential between the source and receiver, with the increasing closeness of the source and receiver to the air-sea interface, with decreasing transmission range, and when transmitting across the thermocline as opposed to transmitting exclusively within the mixed layer.

The time interval between uncorrelated observations was found to be shortest near the surface as opposed to at depth, to increase with increasing source/receiver depth differential, and to decrease when transmitting across the thermocline as opposed to transmitting entirely within the mixed layer.

The magnitude of the variability in transmission loss experienced under the varying conditions ranges over one order of magnitude from 10 db^2 in the near horizontal transmission in the mixed layer at 8 KC to 100 db^2 crossing the thermocline in the 25 KC case. Such figures are only estimates and as such are subject to statistical variation, but the trends in magnitude of the variability appear to be consistent in the various cases considered. Therefore, the magnitudes of the variability determined in this study may be used as approximations of the true variability which will be experienced in the corresponding environmental situation.

In conclusion, it is observed that the factors which influenced the nature and magnitude of the variability in transmission loss are exactly the same as those found in the AMOS study to influence the mean transmission loss (ref. 5). In particular, the factors of source and receiver depth, mixed layer depth, transmission range and surface temperature were used to determine the mode of transmission of a given transmitted signal. The transmission loss expected was then calculated using an equation peculiar to this specific transmission mode.

In a like manner it was suggested that the nature of the variability in transmission loss may be more adequately classified and the magnitude of the variability more precisely specified if the observed change in transmission losses were further indexed and examined by transmission

mode. It is therefore recommended that this be the next area of investigation in the study of the nature and magnitude of the variability of transmission loss in the ocean.

APPENDIX A

I. DESCRIPTION OF DATA

A. TAPE RECONSTRUCTION

The information as received from the U. S. Underwater Sound Laboratory was in the form of 9, seven-track tapes containing appropriate spacial, temporal, and acoustic information. These tapes have now been consolidated into two nine-track tapes suitable for mounting on the standard IBM tape drive units. One tape contains only the bathythermograph (BT) information while the other contains all other necessary data including acoustic measurements pertinent to this report. Table X displays the information that is recorded on this latter tape. The following information has been omitted from each record on the revised acoustic tape, but is still available on the original seven-track tapes:

1) Ambient noise indicator
2) Wind force (beaufort)
3) Unknown contents following water depth entry

The acoustic tape contains data for cruises 5, 7, 8, 9, 10, 11, and 12. Each record is 72 characters in length although each only utilizes 60 character spaces. The additional 12 spaces have been left blank to allow room for any additional information deemed appropriate and to facilitate

placing this data on a user disc if desired. No special records have been added to indicate the end of a cruise or station. It should be noted that all field entries are in terms of integer numbers with the exception of fields 5, 24, and 27 which will require character format (A-format under FORTRAN IV).

The data for cruises 2 and 3 were deemed inappropriate and therefore not included on the acoustic tape. The reason was that the source/receiver depths and two of the four transmitting frequencies do not correspond to the requirements of this study. That is, both cruises show source depths set at a constant 15 feet while the receiver depth is varied. Consequently, none of this data would be accepted by the computer program. The program requires the comparison of one record with source depth at d_1 feet and the receiver depth of d_2 feet, with another record having the source at depth d_2 and receiver at depth d_1.

B. COMBINING ACOUSTIC DATA

An examination of the original tapes revealed that either 1, 2, or 3 acoustic measurements were taken for each particular location, time, and range. Hence, some method must be employed to combine these sets of data in order that they be consistent. One approach would have been to take an average each time a grouping of two or three measurements was encountered. Another approach, and the one subsequently

adopted, would be to simply sum the acoustic data for groupings of three measurements, sum and multiply by 3/2 for groupings of two, and triple any single entries. The resulting figures would then be entered on the revised acoustic tape in place of the old transmitting frequency data, giving a single entry for each particular location, time, and range. This latter method was utilized in the interest of conserving valuable computer time, and in consideration of computational and programming ease. In summary, all acoustic field entries at each of the four transmitting frequencies must be divided by 3 before they can be used in any computations.

C. BATHYTHERMOGRAPH PATTERN CODE AND ITS USE

The bathythermograph (BT) pattern code is a two digit number and will be found in fields 18 and 20 on the acoustic tape.

Interpretation of the code has been simplified for use within this study. Figure (3) indicates the general nature of the thermal structure. To use the figure, enter with the first digit of the code across the top. This gives a picture of the approximate temperature gradient down to 100 feet (associated depths may be read in the '1st digit' column). Next, enter with the second digit. This gives a picture of the approximate temperature gradient from 100 to 250 feet. Connecting the two pictures thus obtained results in a complete recap of the thermal conditions from 0 to 250 feet.

Depths (ft)

1st digit	2nd digit
0	100
30	150
50	200
100	250

Pattern Code Digit

1 2 3 4 5 6 7 8

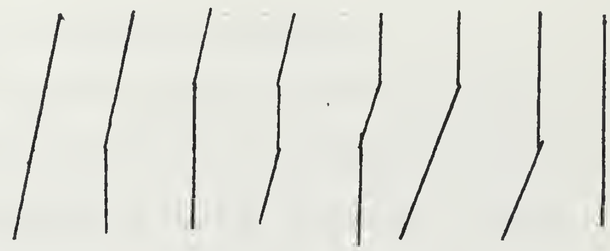

Figure 3. - BT Pattern Code Interpretation

This BT pattern code information was used to establish the position of the mixed layer.

APPENDIX B

I. EXPLANATION OF COMPUTER PROGRAM

This section has been included in the report in order that the program may be used as a base for further studies in the field of temporal and spacial effects on the variation of decibel loss underwater. The entire program has been written and compiled under FORTRAN IV, G-level.

A. GENERAL EXPLANATION

The program is designed to read one data record at a time from the acoustic tape, check the appropriate data against the parameters established by the input array, and, if possible, pass the entire record to subroutine COMP1. Subroutine COMP1 then separates the records passed to it into four categories according to range between the transmitting and receiving ships, the range break point, and source and receiver depths. For example, if the source/receiver depths are either 20/100 or 100/20 feet and the range break point is 5,000 yards, the categories are:

Category	Source/Receiver Depth	Range Interval
I	20/100	$\leq$ 5,000 yards
II	20/100	$>$ 5,000 yards
III	100/20	$\leq$ 5,000 yards
IV	100/20	$>$ 5,000 yards

Once this data has been collected for a single station, the appropriate slope information is computed by subroutine RGRESS and the next station is then processed through the main program, COMP1, and RGRESS.

At the end of each cruise, the processed records are sent to subroutine COMP. This routine computes the change in transmission (db) loss in a sequential manner. That is, a record can never be used in a computation more than once. The computation of Δ db loss proceeds in the following manner:

1) At any given time, two adjacent records are considered.
2) The program computes the difference between ranges of the two records. If this difference is greater than the specified amount 'Z', then no computation is made and the next data set is picked up.
3) If the range difference is less than or equal to the specified amount, Z, then the change in db loss is calculated.

Of the two records being considered at any particular time, the decibel loss of the second is adjusted in the direction of the first record with respect to the difference in range associated with the two records. This is the point at which the slope information passed from subroutine COMP1 is utilized. The only exception to this computational procedure

is when one range falls below the break point and the other above. In that event, both db losses are adjusted to the range break point. Once a computation has been completed, the change in decibel loss and the time difference between the two records are stored in appropriate arrays. At the end of each cruise, this information may be plotted at the users option. Also within this subroutine are two arrays which collect the same information for all cruises to facilitate a cumulative plot.

At the end of the tape, the program calls subroutines SIGMA and BTLAYR. SIGMA simply sorts the Δdb losses with respect to their associated time increments into 5 and then 15 minute intervals, computes the variance within each interval, and plots the variance vs. the change in time. It also calculates the variance and standard deviation over all data passed to it at the end of each tape iteration.

BTLAYR is designed to consider all comparisons which lead to computation of Δdb loss in subroutine COMP, and separate the pairs of observations into one of three categories: 1) above the layer, 2) transmitter and receiver both below the layer, and 3) all transmissions with the receiver and source neither above or below the thermocline. Once all records have been categorized, the change in db loss vs. change in time may be plotted at the users option. Next subroutine SIGMA is called, which computes the

appropriate output as described above for each of the three transmission categories.

Subroutine SIME solves simultaneous linear equations necessary to subroutine RGRESS. OSPLOT is a standard IBM plotting package and is used exclusively for plotting within the program.

B. INPUT SPECIFICATIONS AND DESCRIPTION

An input array has been established in order to lend a certain amount of flexibility in filtering data through specific parameters. This information must be punched on computer cards for inclusion at the end of the program and will be either integer or alphabetic in nature. There must be six entries on each card with the last letter of the numeral entered successively in columns 6, 12, 18, 24, 30, 36, 42, 48, 54, 60, and 66. The last 9 entries on the last card may be left blank. Table XI fully explains what information is required and gives a general description of the input variables. The input data is read into the NK array. Note that NK(15) and NK(17) require a character format. Tables XII and XIII describe the arrays and variables used within the computer program.

C. READING DATA FROM THE ACOUSTIC TAPE

The acoustic tape data format is described by Table X. There is one peculiarity which exists within the formatting structure. Note that the range between the two ships is

divided into two separate field entries. In this case it is necessary to compute the range in the following manner (tape records are loaded into the IN array):

$$\text{Range} = \text{IN}(9) + 1{,}000 \times \text{IN}(8)$$

All data on the tape is integer in nature except fields 5, 6, 24 and 27, which are alphameric.

D. ESTABLISHING THE MIXED LAYER DEPTH

Within each pair of compared data sets are four BT pattern codes, one per ship per record. Since there exists a change in time and a range differential between data sets, it seemed appropriate to combine the depths associated with the pattern codes in some manner. One acceptable method and the one adopted, takes an average of the associated thermal layer depths across records first for the transmitting ship, and then the receiving ship. This averaging is done in the same manner for determining both the top and the bottom of the thermocline. Once this has been accomplished, the minimum of the two top of the layer, and the maximum of the two bottom of the layer averages are selected to represent the upper and lower bounds of the thermocline respectively.

As an example, consider some BT pattern code X_1X_2, where it was desired to determine both the top and the bottom of the thermocline. Computing the top and bottom of the thermocline was done in the following manner:

1) Determining the top of the thermocline (enter with X_1)

X_1	Depth (ft)	X_2	Depth (ft)
1	0	1	100
2	0	2	100
3	see X_2	3	100
4	0	4	100
5	30	5	150
6	30	6	150
7	50	7	200
8	see X_2	8	600

2) Determining the bottom of the thermoline (enter with X_2)

X_2	Depth (ft)	X_1	Depth (ft)
1	300	1	100
2	200	2	50
3	150	3	30
4	300	4	100
5	300	5	50
6	300	6	100
7	300	7	100
8	see X_1	8	600

Note that when checking for the top of the thermocline that when $X_1 = 3$ or 8, this implies looking at the second digit.

Likewise, when determining the bottom of the thermocline and $X_2 = 8$, then look at the first digit.

TABLE I.

Average Slopes Pooled Over All Possible Data

Source/Receiver Depth (ft.)	Cruise No.	Slope d_1/d_2* ≤ 5 Kyds	Slope d_1/d_2* >5 Kyds	Slope d_2/d_1* ≤ 5 Kyds	Slope d_2/d_1* >5 Kyds
50/200	5		.003113	.06622	.001893
	7				.001978
	8	.003122	.001446		
	9	.004476	.001040		
	10	.003580	.001894		
	11	.010430	.000683		
30/150	9	.004950	.000759		.000358
	10	.004975	.001400	.004202	.001356
20/100	5	.028020	.002022	.023260	.003018
	7		.0019581		.002236
	8	.005097	.001348	.004221	.015560
	9	.009709	.001062	.008700	.001550
	11	.009000	.001000	.010100	.001000
50/400	8	.003831	.001400	.003430	.001358
	9	.004455	.001191		
	10	.003607	.001924		
	11	.011110	.000997		
100/400	5		.000599		
	7		.000930		
	8	.004718	.001453	.001964	.001313
	9	.006369	.001229		
	10	.003980	.001434		
	11	.016850	.001105		

*Source/receiver depths

TABLE II.

Summary of Kolmogorov-Smirnov Goodness-of-Fit Test

Source/ Receiver Depth (ft.)	Latitude	Longitude	Time Interval (min.)	Range Interval (Kyds)	XMT Freq (Kc)	Sample Size	Std. Dev.	D_{max}	Critical Value	Significance* Level (α)
20/100	All	All	0-120	0-30	8	293	4.86	.06276	.0665	.15
20/100	All	All	15-30	0-30	8	128	4.51	.0884	.0917	.10
20/100	All	All	30-45	0-30	8	86	5.71	.1024	.1157	.20
20/100	All	All	0-120	10-30	8	75	3.69	.1133	.1235	.20
20/100	0-50N	0-60W	0-120	0-30	25	94	8.52	.1277	.140	.05
30/150	All	All	0-120	0-30	8	48	4.02	.1627	.1640	.15
50/100	All	All	0-120	0-30	8	384	4.79	.1029		less than .01
50/100	50-80N	All	0-120	0-30	8	170	3.97	.10248	.1041	.05
50/100	0-50N	0-60W	0-120	0-30	25	111	6.13	.0327	.1015	.20
50/100	0-50N	0-60W	0-15	0-30	25	62	6.32	.1648	.1725	.05
50/250	All	All	0-120	0-30	8	199	4.62	.107	.120	.01
50/250	50-80N	All	0-120	0-30	8	133	4.25	.1387	.1420	.01
50/250	50-80N	All	0-120	0-10	8	100	3.78	.1281	.1360	.05
50/400	All	All	0-120	0-30	8	44	5.13	.0528	.1615	.20
100/400	All	All	0-120	0-30	8	47	4.53	.0830	.2000	.20
100/500	50-80N	All	0-120	0-30	25	92	8.19	.1009	.1115	.20
100/500	50-80N	All	30-45	0-30	25	43	7.22	.0819	.1635	.20

*In the sense of failing to reject the null hypothesis.

TABLE III.

The Effect of Source/Receiver Depth on Var (y(Δ t))

(Cruise 10 only)

Source/ Receiver Depth (ft.)	Lati- tode (deg)	Longi- tude (deg)	Trans- mit- ting Range (Kyds)	Trans- mit- ting Freq (Kc)	Range on Δ t (minutes) 0-15	15-30	30-45	45-60	60-75	75-90
30/50	All	All	0-30	8	16.1(19)	10.3(28)	20.5(6)		8.7(1)	
30/100	All	All	0-30	8		21.7(21)	56.4(25)	2.6(4)	3.8(1)	
30/150	All	All	0-30	8		.5(3)	33.9(14)	15.7(12)	6.5(4)	
30/250	All	All	0-30	8			1.1(5)	11.5(15)	27.7(13)	9.1(7)
30/500	All	All	0-30	8		.9(3)	12.6(3)	13.5(9)	25.8(7)	45.2(7)
50/100	All	All	0-30	8	10.4(34)	5.9(18)	5.1(3)	.0(1)		
50/100	All	All	0-30	8		6.9(23)	7.8(20)			
50/250	All	All	0-30	8		1.9(11)	8.9(14)	18.9(19)	.5(1)	.3(1)
50/500	All	All	0-30	8			12.1(9)	6.9(11)	22.5(15)	4.3(4)
100/150	All	All	0-30	8	2.0(21)	4.7(23)	.9(1)			
100/250	All	All	0-30	8	1.2(2)	7.8(32)	21.9(16)	.5(1)	.4(1)	
100/500	All	All	0-30	8		25.4(7)	5.6(19)	8.5(10)	20.2(4)	5.8(2)
150/250	All	All	0-30	8	3.2(27)	25.6(15)	5.0(1)			29.9(2)
250/500	All	All	0-30	8	3.3(23)	15.2(26)	37.4(3)			

TABLE IV.

The Effect of Mixed Layer on Var $(y(\Delta t))$

Source/Receiver Depth (ft.)	Above*	Crossing**
20/100	14.8	28.4
20/500	57.2	58.7
30/150	19.2	-
50/100	20.5	24.9
50/250	5.6	25.7
50/400	18.6	28.5
50/500	14.6	34.3
100/400	11.7	25.4
100/500	12.0	41.5

*Both source and receiver in the mixed layer

**At least source or receiver below the mixed layer, i.e., crossing the thermocline

TABLE V.

The Gross Effect of Geographic Location

on Var (Δ db loss) - 8 Kc

Source/Receiver Depth (ft.)	Latitude (degs)	Longitude (degs)	Crossing**	Above***
20/100	All	All	28.30(192)*	14.82(101)
	50-80N	All	23.12(111)	2.60(2)
	0-50N	0-60W	37.60(65)	12.29(57)
	0-50N	60-90W	8.30(5)	19.16(22)
50/100	All	All	24.95(216)	20.53(167)
	50-80N	All	20.00(115)	6.77(55)
	0-50N	0-60W	29.96(79)	27.56(63)
	0-50N	60-90W	25.95(11)	29.10(29)
50/250	All	All	25.71(151)	7.53(48)
	50-80N	All	23.54(94)	4.86(39)
	0-50N	0-60W	20.52(35)	24.61(6)
	0-50N	60-90W	43.26(22)	7.89(3)
100/500	All	All	41.58(116)	11.97(40)
	50-80N	All	39.39(87)	12.51(34)
	0-50N	0-60W		
	0-50N	60-90W	49.87(28)	.43(3)

*( ) - Indicates sample size.

**At least source or receiver below mixed layer.

***Both source and receiver in the mixed layer.

TABLE VI.

The Effect of Geographic Location on Var $(y(\Delta t))$

Source/ Receiver Depth (ft.)	Latitude (deg)	Longitude (deg)	XMT Freq. (Kyds)	XMT Freq. (Kyds)	Mixed Layer Code	Range on Δt(minutes) 0-15	15-30	30-45	45-60	60-75	75-90
20/100	All	All	0-30	8	C	29.4(3)*	22.6(120)	41.2(57)	11.1(6)	53.1(3)	53.6(3)
	All	All	0-30	8	A	7.0(11)	15.9(59)	15.8(29)			
50/100	All	All	0-30	8	C	28.8(141)	28.1(71)	10.4(3)			
	All	All	0-30	8	A	18.2(112)	29.1(45)	10.7(8)			
50/250	All	All	0-30	8	C	11.5(2)	33.4(58)	23.4(56)	17.6(29)	6.4(4)	
	All	All	0-30	8	A		9.3(19)	7.8(14)	10.3(13)		
100/500	All	All	0-30	8	C		24.6(28)	51.4(52)	29.4(25)	71.4(10)	
	All	All	0-30	8	A		5.8(10)	7.3(19)	10.5(8)		
20/100	50-80N	All	0-30	8	C	16.5(71)	39.6(34)	13.1(3)			
	50-80N	All	0-30	8	A		2.6(2)				
50/100	50-80N	All	0-30	8	C	20.6(78)	25.5(36)				
	50-80N	All	0-30	8	A	8.4(41)	1.5(10)	2.5(3)			
50/250	50-80N	All	0-30	8	C		30.1(32)	25.7(39)	11.4(19)	5.4(3)	
	50-80N	All	0-30	8	A		2.5(12)	4.8(13)	8.0(12)		
100/500	50-80N	All	0-30	8	C	26.3(18)	51.2(41)	14.8(21)	89.4(6)		
	50-80N	All	0-30	8	A	2.3(7)	7.4(17)	11.9(7)			

20/100	0-50N	0-60W	0-30	8	C		34.2(7)	44.6(21)	9.1(3)	79.7(2)	27.2(2)
	0-50N	0-60W	0-30	8	A	3.0(7)	13.7(33)	14.0(16)			
50/100	0-50N	0-60W	0-30	8	C	25.3(46)	39.1(30)	10.4(3)			
	0-50N	0-60W	0-30	8	A	17.9(42)	56.3(17)	7.1(4)			
50/200	0-50N	0-60W	0-30	8	C	24.0(8)	14.5(14)	28.5(10)			
	0-50N	0-60W	0-30	8	A	15.8(4)	46.4(1)	37.9(1)			
100/500	0-50N	0-60W	0-30	8	C		24.1(9)	52.5(11)	105.9(4)	44.5(4)	
	0-50N	0-60W	0-30	8	A		.5(2)				
20/100	0-50N	60-90W	0-30	8	C		10.3(4)				
	0-50N	60-90W	0-30	8	A	13.9(4)	20.5(11)	23.1(16)			
50/100	0-50N	60-90W	0-30	8	C	24.9(9)	34.0(2)				
	0-50N	60-90W	0-30	8	A	45.9(14)	12.2(13)				
50/250	0-50N	60-90W	0-30	8	C	18.2(1)	42.9(18)	53.8(3)			
	0-50N	60-90W	0-30	8	A		7.9(3)				
100/250	0-50N	60-90W	0-30	8	C		.1(1)				
	0-50N	60-90W	0-30	8	A		40.6(1)	5.9(2)			

*( ) indicates sample size.

**C - At least source or receiver below mixed layer.
A - Both source and receiver in the mixed layer.

TABLE VII.

The Effect of Transmitting Frequency on Var $(y(\Delta t))$

Source/ Receiver Depth (ft.)	Lati- tude (deg)	Longi- tude (deg)	XMT Freq. (Kyds)	XMT Freq. (Kyds)	Mixed Layer Code	Range on Δt(minutes) 0-15	15-30	30-45	45-60	60-75	75-90
20/100	All	All	0-30	8	C	29.4(3)*	22.6(120)	41.2(57)	11.1(6)	53.1(3)	53.6(3)
	All	All	0-30	8	A	7.0(11)	15.9(57)	15.8(29)			
	All	All	0-30	25	C	20.3(2)	96.4(71)	98.6(52)	42.0(5)	184.2(3)	37.7(3)
	All	All	0-30	25	A	19.2(10)	39.5(49)	80.7(26)			
50/100	All	All	0-30	8	C	28.8(141)	28.1(71)	10.4(3)			
	All	All	0-30	8	A	18.2(112)	29.1(45)	10.7(8)			
	All	All	0-30	25	C	38.7(87)	35.7(60)	30.1(3)			
	All	All	0-30	25	A	18.0(81)	12.8(40)	7.3(8)			
50/250	All	All	0-30	8	C	11.5(2)	33.4(58)	23.4(56)	17.6(29)	6.4(4)	
	All	All	0-30	8	A		9.3(19)	7.8(14)	10.3(13)		
	All	All	0-30	25	C		58.8(30)	32.4(36)	59.1(25)	44.4(4)	
	All	All	0-30	25	A		12.8(8)	10.4(10)	5.4(13)		
100/500	All	All	0-30	8	C		24.6(28)	51.4(52)	29.4(25)	71.4(10)	
	All	All	0-30	8	A		5.8(10)	7.3(19)	10.5(8)		
	All	All	0-30	25	C		108.6(15)	55.3(38)	94.0(23)	98.0(9)	
	All	All	0-30	25	A		8.7(6)	27.9(12)	25.1(8)		
20/100	50-80N	All	0-30	8	C		16.5(71)	39.6(34)	13.1(3)		
	50-80N	All	0-30	8	A		2.6(2)				
	50-80N	All	0-30	25	C		113.8(39)	117.3(30)	100.8(2)		
	50-80N	All	0-30	25	A		54.5(2)				

TABLE VII. (Cont'd)

50/100	50-80N	All	0-30	8	C	20.6(78)	25.5(36)				
	50-80N	All	0-30	8	A	8.4(41)	1.5(10)	2.5(3)			
	50-80N	All	0-30	25	C	31.6(44)	23.2(31)				
	50-80N	All	0-30	25	A	11.4(30)	2.9(8)	3.7(3)			
50/250	50-80N	All	0-30	8	C		30.1(32)	25.7(39)	11.9(19)	5.4(3)	
	50-80N	All	0-30	8	A		2.5(12)	4.8(13)	8.0(12)		
	50-80N	All	0-30	25	C		52.1(14)	21.6(35)	48.4(16)	48.3(3)	
	50-80N	All	0-30	25	A		3.9(6)	9.4(8)	4.2(12)		
100/500	50-80N	All	0-30	8	C		26.3(18)	51.2(41)	14.8(21)	89.4(6)	
	50-80N	All	0-30	8	A		2.3(7)	7.4(17)	11.9(7)		
	50-80N	All	0-30	25	C		135.6(9)	60.5(32)	78.9(20)	160.0(5)	
	50-80N	All	0-30	25	A		17.0(3)	28.7(11)	28.6(7)		
20/100	0-50N	0-60W	0-30	8	C		34.2(37)	44.6(21)	9.1(3)	79.7(2)	27.2(2)
	0-50N	0-60W	0-30	8	A	3.0(7)	13.7(33)	14.0(16)			
	0-50N	0-60W	0-30	25	C		90.3(24)	77.1(20)	2.7(3)	244.4(2)	43.1(2)
	0-50N	0-60W	0-30	25	A	22.3(5)	31.5(25)	125.9(13)			
50/100	0-50N	0-60W	0-30	8	C	25.3(46)	39.1(30)	10.4(3)			
	0-50N	0-60W	0-30	8	A	17.9(42)	56.3(17)	7.1(4)			
	0-50N	0-60W	0-30	25	C	57.3(32)	52.0(3)	30.1(3)			
	0-50N	0-60W	0-30	25	A	22.6(29)	17.7(16)	1.3(4)			
50/250	0-50N	0-60W	0-30	8	C	24.0(8)	14.5(14)	28.5(10)			
	0-50N	0-60W	0-30	8	A	15.8(4)	46.4(1)	37.9(1)			
	0-50N	0-60W	0-30	25	C		46.5(5)	68.6(9)	78.2(9)		
	0-50N	0-60W	0-30	25	A			15.8(2)			
100/500	0-50N	0-60W	0-30	8	C		24.1(9)	52.5(11)	105.9(4)	44.5(4)	
	0-50N	0-60W	0-30	8	A			.5(2)			
	0-50N	0-60W	0-30	25	C		81.6(5)	27.7(6)	194.7(3)	20.5(2)	
	0-50N	0-60W	0-30	25	A		.5(2)				

TABLE VII. (Cont'd)

20/100	0-50N	60-90W	0-30	8	C		10.3(4)	
	0-50N	60-90W	0-30	8	A	13.9(4)	20.5(11)	23.1(6)
	0-50N	60-90W	0-30	25	C		47.8(3)	
	0-50N	60-90W	0-30	25	A	16.2(5)	80.8(12)	30.4(6)
50/100	0-50N	60-90W	0-30	8	C	25.2(9)	34.0(2)	
	0-50N	60-90W	0-30	8	A	45.9(14)	12.2(13)	
	0-50N	60-90W	0-30	25	C	17.4(7)		
	0-50N	60-90W	0-30	25	A	41.2(10)	13.0(11)	
50/250	0-50N	60-90W	0-30	8	C		42.9(18)	53.8(3)
	0-50N	60-90W	0-30	8	A		7.9(3)	
	0-50N	60-90W	0-30	25	C		73.3(12)	57.5(2)
	0-50N	60-90W	0-30	25	A		72.8(11)	52.5(2)

*( ) - Indicates sample size.

**C - At least source or receiver below the mixed layer.
A - Both source and receiver in the mixed layer.

TABLE VIII.

The Effect of Transmission Range on Var ($y(\Delta t)$)

Source/ Receiver Depth (ft.)	Latitude (deg)	Longitude (deg)	XMT Freq. (Kyds)	XMT Freq. (Kyds)	Mixed Layer Code	Range on Δt(minutes) 0-15	15-30	30-45	45-60	60-75	75-90
20/100	All	All	0-10	8	C		27.0(81)	46.4(49)	11.1(6)	53.1(3)	26.6(3)
	All	All	0-10	8	A	6.9(9)	16.8(42)	18.1(23)			
	All	All	10-30	8	C	43.8(2)	14.6(39)	9.0(8)			
	All	All	10-30	8	A	7.5(2)	13.9(17)	6.1(6)			
50/100	All	All	0-10	8	C	30.1(92)	28.6(61)	10.4(3)			
	All	All	0-10	8	A	14.7(72)	14.3(33)	9.5(7)			
	All	All	10-30	8	C	11.8(49)	24.4(10)				
	All	All	10-30	8	A	24.9(40)	68.7(12)				
50/250	All	All	0-10	8	C		73.7(30)	16.0(48)	18.1(28)	6.4(4)	
	All	All	0-10	8	A		1.2(8)	10.2(8)	10.3(13)		
	All	All	10-30	8	C	12.7(2)	34.4(28)	78.2(2)			
	All	All	10-30	8	A		10.3(11)	4.7(6)			
100/500	All	All	0-10	8	C		34.0(14)	50.2(14)	29.4(25)	79.2(9)	
	All	All	0-10	8	A		8.7(5)	9.3(10)	10.5(8)		
	All	All	10-30	8	C		13.9(14)	56.1(11)			
	All	All	10-30	8	A		2.9(5)	5.0(9)			
20/100	50-80N	All	0-10	8	C		19.7(50)	41.3(32)	13.1(3)		
	50-80N	All	0-10	8	A		2.6(2)				
	50-80N	All	10-30	8	C	8.4(20)	15.1(2)				
	50-80N	All	10-30	8	A						

TABLE VIII. (Cont'd)

50/100	50-80N	All	0-10	8	C	25.8(55)	20.5(33)				
	50-80N	All	0-10	8	A	10.7(30)	1.4(7)	5.1(3)			
	50-80N	All	10-30	8	C	7.8(22)	3.3(3)				
	50-80N	All	10-30	8	A	1.6(11)	1.4(3)				
50/250	50-80N	All	0-10	8	C		36.5(15)	14.0(36)	11.9(19)	5.4(3)	
	50-80N	All	0-10	8	A		1.0(6)	5.1(7)	8.0(12)		
	50-80N	All	10-30	8	C		25.5(16)	172.6(3)			
	50-80N	All	10-30	8	A		4.3(6)	4.7(6)			
100/500	50-80N	All	0-10	8	C		35.7(9)	45.4(34)	14.8(21)	106.9(5)	
	50-80N	All	0-10	8	A		.9(3)	9.3(10)	11.9(7)		
	50-80N	All	10-30	8	C		14.0(9)	84.2(6)			
	50-80N	All	10-30	8	A		3.3(4)	4.7(7)			
20/100	0-50N	0-60W	0-10	8	C		45.6(23)	56.2(16)	9.1(3)	79.7(2)	27.2(2)
	0-50N	0-60W	0-10	8	A	1.4(5)	14.2(23)	15.8(12)			
	0-50N	0-60W	10-30	8	C		19.0(14)	5.8(5)			
	0-50N	0-60W	10-30	8	A	7.5(2)	12.7(10)	7.9(4)			
50/100	0-50N	0-60W	0-10	8	C	31.4(28)	39.4(25)	10.4(3)			
	0-50N	0-60W	0-10	8	A	8.5(26)	11.6(12)	2.2(3)			
	0-50N	0-60W	10-30	8	C	15.6(18)	37.6(5)				
	0-50N	0-60W	10-30	8	A	34.4(16)	161.4(5)	21.0(1)			
20/100	0-50N	60-90W	0-10	8	C		13.3(3)				
	0-50N		0-10	8	A	13.8(4)	24.0(9)	26.0(5)			
	0-50N		10-30	8	C						
	0-50N		10-30	8	A		4.6(2)	4.8(1)			

TABLE VIII. (Cont'd)

50/100	0-50N	60-90W	0-10	8	C	26.4(5)	22.4(1)	
			0-10	8	A	49.0(7)	16.1(9)	45.0(1)
			10-30	8	C	21.2(4)	44.8(1)	
			10-30	8	A	43.4(7)	3.5(4)	
50/250	0-50N	60-90W	0-10	8	C		149.9(10)	
			0-10	8	A			
			10-30	8	C		65.7(8)	40.4(2)
			10-30	8	A		12.5(2)	

*( ) - Indicates sample size.

**C - At least source or receiver below the mixed layer.
A - Both source and receiver in the mixed layer.

TABLE IX.

Large Absolute Values of the Change in Transmission Loss

Source/ Receiver Depth (ft.)	XMT Freq. (Kc)	Trans. Loss (db)	Water Depth (fath)	BT Pattern Code 1st Record Ship 1/ Ship 2	BT Pattern Code 2nd Record Ship 1/ Ship 2	Rng (yds)	t (min)	Time of Day	Av Rng (Yds)	Mixed Layer Code
20/100	8	19.33	950	81/71	81/71	40	20	N	8220	C
	8	16.57	820	12/61	16/61	190	30	N	5000	C
	8	15.54	2950	11/41	11/64	140	32	N	4910	C
	8	15.49	750	81/83	31/83	200	25	N	5420	A
	8	12.96	2850	88/67	88/67	380	35	N	4310	A
	8	12.52	1200	72/72	78/72	380	72	N	3110	C
	8	12.40	1300	11/11	11/11	200	35	D	3250	C
	8	12.32	2350	73/71	73/61	240	26	N	3500	C
	8	11.63	1720	61/71	62/61	280	40	N	1440	C
	8	11.44	1300	21/71	11/82	50	30	D	3625	C
	8	11.00	800	58/83	58/83	500	21	N	13650	C
	8	10.86	2000	56/74	36/45	330	33	N	7650	C
	8	10.67	1350	56/32	36/32	100	36	D	1400	C
	8	10.62	2875	71/71	41/71	240	20	N	8470	C
	8	10.62	870	71/71	61/71	350	32	N	3175	C
	8	7.99	1300	16/18	17/18	250	22	N	4878	C
	8	9.61	820	11/11	41/41	140	30	D	5000	C
	8	9.51	1960	88/65	78/65	80	22	D	5400	C
	8	9.48	1200	72/72	72/72	500	41	D	1250	C
	8	9.38	2860	85/81	85/86	360	23	N	4680	A
	8	9.34	2640	62/52	62/52	100	18	D	24000	C
	8	9.34	1500	- /72	71/21	40	35	D	7980	C
	8	9.20	2850	82/54	82/54	150	30	D	3425	C

TABLE IX. (Cont'd)

50/100	8	28.29	2300	82/83	82/83	60	22	D	12030	A
	8	17.21	2240	55/22	75/22	110	20	N	8385	C
	8	17.02	1300	81/83	81/83	100	10	N	4750	A
	8	16.67	1330	62/15	62/15	20	14	N	1450	C
	8	15.93	2000	36/45	36/45	170	13	N	7585	C
	8	13.68	2840	88/87	88/87	200	5	N	11880	A
	8	13.65	1680	88/88	88/88	40	13	D	5080	A
	8	13.13	2620	88/87	88/87	140	10	D	12630	A
	8	12.63	2240	15/65	15/65	10	13	N	2925	C
	8	12.29	2520	15/18	15/17	100	26	D	16950	C
	8	12.17	2950	11/14	11/64	120	21	N	4920	C
	8	12.09	1300	21/71	11/28	20	16	D	3710	C
	8	11.77	2040	87/88	87/88	60	8	N	5770	A
	8	11.65	950	88/71	88/71	40	10	N	8220	A
	8	11.21	2350	72/61	72/65	50	15	N	4775	C
	8	11.00	2565	82/85	82/85	0	10	D	7920	A
	8	10.58	2250	81/81	81/81	100	13	N	12250	A
	8	10.47	1000	72/72	72/82	120	13	D	3260	C
	8	10.13	1370	81/86	81/86	80	10	D	8360	A
	8	10.12	2975	88/88	88/88	60	10	D	12650	A
	8	10.08	2840	53/88	53/88	50	5	N	7925	A
	8	9.86	950	62/12	62/12	20	12	N	1530	C
	8	9.71	870	71/71	71/61	260	20	D	3180	C
	8	9.52	1960	71/ -	71/ -	140	17	D	12630	C
	8	9.07	960	41/37	41/37	180	26	N	5690	C
50/250	8	22.06	1200	- /11	- /11	100	31	N	24250	C
	8	20.97	2565	72/86	82/86	60	20	N	18270	C
	8	15.82	630	65/15	65/16	210	23	N	5625	C
	8	12.90	2520	67/64	17/67	200	56	D	3700	C
	8	12.23	2925	85/88	85/88	50	20	D	3675	A
	8	11.81	2760	71/71	71/71	180	25	D	2810	C
	8	11.16	630	66/61	75/71	200	20	N	24000	C

TABLE IX. (Cont'd)

50/250	8	10.33	1700	14/14	14/31	100	47	N	3650	C
	8	10.06	870	71/21	61/71	290	20	D	3065	C
	8	9.70	1700	11/44	11/14	50	33	N	5475	C
	8	9.22	2925	- /86	- /86	270	30	D	3515	A
100/500	8	20.93	1920	62/61	71/61	60	37	N	1550	C
	8	20.53	1200	72/72	71/72	80	49	N	5200	C
	8	19.64	1200	71/72	71/71	40	40	N	5140	C
	8	17.17	1330	12/12	13/13	80	40	N	2840	C
	8	16.17	1350	36/32	26/85	50	71	D	1325	C
	8	15.99	1200	- /11	- /11	100	32	N	24250	C
	8	15.69	1200	11/65	11/12	200	31	D	17400	C
	8	14.79	820	11/11	11/11	260	67	D	5010	C
	8	13.95	1680	88/88	88/88	50	115	D	3295	A
	8	13.84	630	76/61	76/62	200	23	N	9120	C
	8	13.37	1330	23/63	82/63	120	33	N	8360	C
	8	11.44	630	65/16	61/71	280	25	N	5560	C
	8	11.33	1330	72/72	72/72	0	41	D	5200	C
	8	10.89	840	61/11	11/11	300	160	D	6150	C
	8	10.69	1330	74/64	72/61	10	35	D	5385	C
	8	10.09	630	75/71	75/71	300	20	N	24150	C
	8	10.09	1700	11/44	12/14	90	33	N	5495	C
	8	10.03	1200	78/72	72/74	170	61	N	2765	C
	8	10.02	2600	78/88	88/88	40	26	N	7860	C
	8	9.50	1810	11/11	11/61	150	54	D	3625	C
	8	9.41	2000	74/81	74/71	280	44	N	1940	C
20/100	8	35.04	1330	12/15	12/12	100	29	N	2830	C
	8	31.20	2850	88/85	87/85	150	30	D	3425	A
	8	30.55	1350	26/85	25/31	100	25	D	3550	C
	8	29.79	1350	26/32	26/31	100	26	N	5450	C
	8	29.23	820	11/11	41/41	140	30	D	4950	C
	8	24.99	1000	62/72	72/82	60	41	D	3230	C

TABLE IX. (Cont'd)

20/100	25	24.53	750	38/28	33/28	200	25	N	5420	C
	25	22.93	1200	72/72	72/72	500	41	D	1250	C
	25	22.73	1350	86/87	86/87	60	15	D		A
	25	21.96	1200	72/72	78/72	380	72	N	3110	C
	25	20.36	750	48/18	45/18	460	22	N	8830	C
	25	16.91	2300	51/71	61/71	60	23	D	5220	C
	25	16.67	1700	11/14	14/31	0	27	N	3700	C
	25	15.44	1300	21/71	11/82	50	30	N	3675	C
	25	14.807	1610	61/11	61/11	100	35	N	3600	C
	25	14.31	820	61/66	41/61	60	25	N	4830	C
	25	14.27	2850	58/28	58/37	200	30	N	9200	C
	25	14.20	1330	72/52	72/72	100	46	D	5150	C
	25	12.93	1000	71/72	71/82	50	28	N	5025	C
	25	12.90	1740	83/87	75/77	20	37	D	8430	C
	25	12.75	2620	81/34	81/34	125	21	D	5040	A
	25	12.67	2250	81/81	81/81	0	32	N	8020	A
	25	12.52	2750	88/88	88/88	200	41	N	3300	A
	25	12.34	870	72/71	71/61	260	25	D	5030	C
	25	12.33	2875	61/12	61/12	0	22	N	3500	C
	25	11.33	2100	88/35	88/35	150	17	D	4525	A
	25	11.19	2620	88/88	88/88	500	31	D	8250	A
	25	11.00	840	71/61	66/61	0	28	N	6240	C
	25	10.95	2850	87/85	87/85	20	24	D	5290	A
	25	10.78	2850	16/62	16/62	150	20	D	5225	C
	25	10.53	2550	83/83	82/83	350	30	N	11725	A
	25	10.39	2350	73/71	73/61	240	26	N	3740	C
	25	10.38	2860	85/81	85/86	360	23	N	4680	A
	25	10.38	2620	87/88	88/88	360	35	D	3140	A
	25	10.33	1960	- /71	- /71	200	25	D	3300	
	25	10.27	3020	86/88	86/88	60	35	D	3030	A
	25	9.96	2400	38/38	38/23	200	29	D	8080	C
	25	9.89	2300	- /81	- /82	100	24	D	5050	
	25	9.71	1970	88/88	88/88	230	36	N	12235	A

TABLE IX. (Cont'd)

20/100	25	9.66	1330	73/64	74/64	60	32	D	5410	C
	25	9.50	2770	85/85	87/85	0	12	N	3280	A
	25	9.44	1600	81/71	81/71	20	22	N	3160	C
	25	9.37	950	62/12	72/12	60	23	N	1550	C
100/500	25	28.83	1920	71/74	72/71	300	22	N	4070	C
	25	23.67	1550	- /72	- /71	0	66	N	1250	C
	25	22.02	1200	72/72	71/72	80	49	N	5200	C
	25	21.24	1550	- /71	- /61	220	45	N	2710	
	25	18.61	1350	26/31	26/22	60	39	N	5530	C
	25	16.79	1700	11/44	12/14	90	33	N	5495	C
	25	16.22	840	41/61	41/11	100	41	D	5950	C
	25	15.00	1330	72/72	72/72	0	41	D	5200	C
	25	14.65	820	71/ -	61/ -	120	49	D	5510	
	25	14.57	630	76/61	76/62	200	23	N	9120	C
	25	14.22	1700	14/14	11/14	300	55	N	3550	C
	25	13.89	1200	61/11	61/11	150	52	N	3475	C
	25	12.94	1680	88/88	88/88	180	55	D	1160	A
	25	12.67	820	61/62	61/66	0	59	N	4800	C
	25	12.34	2520	65/72	12/73	450	23	D	8225	C
	25	11.50	1600	88/88	88/ -	120	31	D	2960	A
	25	11.11	1200	72/72	74/73	150	24	D	875	C
	25	11.00	820	12/11	12/61	200	53	D	5000	C
	25	10.67	1300	71/11	61/61	0	43	D	950	C
	25	10.50	1810	11/11	11/61	150	54	D	3625	C
	25	10.45	1330	23/63	82/63	120	33	N	8360	C
	25	10.39	820	11/11	11/11	260	67	D	5010	C
	25	10.10	840	61/61	71/61	200	60	N	6340	C
	25	9.88	1330	72/72	72/61	10	35	D	5385	C
	25	9.17	1330	83/87	- /87	20	22	D	2850	C

TABLE X.

Acoustic Data Records

Field	Columns	Format	Description	
1	1-2	I 2	Cruise Number	
2	3-4	I 2	Station Number	
3	5-6	I 4	Hours (GCT)	
4	7-8		Minutes (GCT)	
5	9	A 2	Sign of Time Zone	
6	10		Time Zone	
7	11-12	I 2	Day	
8	13-14	I 2	Month	
9	15-16	I 2	Year	
10	17-18	I 2	Range (thousands of yards)	
	19-21	I 3	Range (hundreds of yards)	
11	22	I 1	Receiving Ship	
12	23-25	I 3	South depth (ft.)	
13	26-28	I 3	Receiver depth (ft.)	
14	29-31	I 3	Propogation loss (db) 2.2 KC	
15	32-34	I 3	Propogation loss (db) 8 Kc	
16	35-37	I 3	Propogation loss (db) 16 Kc	
17	38-40	I 3	Propogation loss (db) 25 Kc	
18	41	I 1	Sea State)	Ship 1
19	42-43	I 2	BT Pattern Code)	
20	44	I 1	Sea State)	Ship 2
21	45-46	I 2	BT Pattern Code)	
22	47-48	I 2	Degrees (latitude)	
23	49-50	I 2	Minutes (latitude)	
24	51	I 1	N or S	
25	52-53	I 2	Degrees (longitude)	
26	54-55	I 2	Minutes (longitude)	
27	56	I 1	E or W	
28	57-60	I 4	Water depth (fathoms)	

TABLE XI.

Input Array Description - NK(I)

I	Description
1	Cruise number, Zero implies all cruises, otherwise specify cruise number desired.
2	Station number. Zero specifies all stations, otherwise specify station number desired.
3	Time (GCT). Zero implies all times, otherwise specify lower bound on time interval desired.
4	Time (GCT). Same as NK(3) except specify upper bound on desired time interval.
5	Time zone. Zero implies all time zones, otherwise specify desired time zone. If negative time zone, fill in first with negative sign, otherwise leave first character blank.
6	Month. Zero implies all months, otherwise fill in lower bound no month interval desired.
7	Month. Same as NK(6) except specify upper bound on month interval desired.
8	Year. Zero implies all years, otherwise specify year desired.
9	Range. Zero implies all ranges, otherwise specify lower bound on range interval.
10	Range. Same as NK(9) except specify upper bound.
11	Receiving ship. Zero implies both ships, 1 implies Ship No. 1, 2 implies Ship No. 2.
12	Source depth. Specify source depth desired.
13	Receiver depth. Specify receiver depth desired.
14	Latitude. Zero implies all latitudes. This is a packed word which expresses latitude in degrees and thousandths of degrees. For example: 40.817 degrees will be put in the array as 40817, and

TABLE XI. (Cont'd)

14 (cont'd)	31.7 as 31700. This will always be the lower limit. If working with a N/N or S/S situation, enter the smaller of the two latitudes. If working with a N/S situation, enter the north latitude.
15	N or S. This will always be an N for the N/S situation.
16	Latitude. Zero implies all latitudes. This is a packed word (see NK(14)). This will always be the upper bound on the latitude interval. If working with a N/N or S/S situation, enter the larger of the two latitude limits. If a N/S situation, enter the south latitude.
17	N or S. This will always be S for N/S situation.
18	Longitude. Zero implies all longitudes. This is a packed word (see NK(14)). This will always be the lower limit. If working with E/E or W/W situation, enter the smaller of the two longitudes. If E/W situation, enter the east longitude.
19	E or W. This will always be E for E/W situation.
20	Longitude. Zero implies all longitudes. This is a packed word (see NK(14)). This is always the upper limit on longitude. Enter the larger of the two longitudes here if a E/E or W/W situation. Enter west longitude for E/W situation.
21	E or W. If E/W situation, enter W here.
22	Water depth. -1 implies all depths, otherwise specify lower limit.
23	Water depth. Same as NK(22) except specify upper limit.
24	Transmitter frequency. 13, 14, 15 and 16 imply 2.2, 8, 16, and 25 kc respectively.
25	Number of stations in cruise 5.
26	Range differential between pairs of observations.

TABLE XI. (Cont'd)

27	Number of stations cruise 7.
28	Number of stations cruise 8.
29	Number of stations cruise 9.
30	Number of stations cruise 10.
31	Number of stations cruise 11.
32	Number of stations cruise 12.
33	Enter first cruise number to be used.
34	Specify range break point.
35	Number of repetitions of program desired. Must have a complete set of input data cards for each iteration.

TABLE XII.

Description of Arrays

Arrays	Description
A	Stores the time difference within pairs of observations by cruises.
A1	Accumulates time differences over all cruises.
AT	Stores time differences for pairs of observations that have both receiver and transmitter neither above or below the thermocline.
AU	Stores time differences for pairs of observations that have both receiver and transmitter above the thermocline.
AV	Stores time differences for pairs of observations with both transmitter and receiver below the thermocline.
B	Stores the difference between adjusted transmission losses within pairs of observations by cruises.
B1	Accumulates adjusted transmission loss differences over all cruises.
BT	Same as AT for transmission loss differences.
BU	Same as AU for transmission loss differences.
BV	Same as AV for transmission loss differences.
DB1	Decibel loss for Case I.*
DB2	Decibel loss for Case II.*
DB3	Decibel loss for Case III.*
DB4	Decibel loss for Case IV.*
DBO	Combines db losses for Cases III and IV.*
DB	Combines db losses for Cases I and II.*

TABLE XII. (Cont'd)

IDB	Stores first and second digits for BT pattern code.
IK	Array MK is loaded into this array one record at a time for computations in subroutine COMP.
IN	Loaded sequentially with records from the acoustic data tape in the main program.
J	Establishes midpoints of five-minute intervals in subroutine SIGMA.
LLX1	Stores BT pattern code for Ship No. 1 and 1st data set in pair.
LLX2	Stores BT pattern code for Ship No. 2 and 1st data set in pair.
LLX3	Stores BT pattern code for Ship No. 1 and 2nd data set in pair.
LLX4	Stores BT pattern code for Ship No. 2 and 2nd data set in pair.
MK	Stores records from acoustic tape that have the same cruise no.
MMK	Temporary storage for acoustic tape records when a different cruise number other than the one being considered is encountered. Will be placed in the MK array after computations are completed for the previous cruise.
N	Counts entries in each five-minute interval in subroutine SIGMA.
NK	The input parameters.
NY	Counts entries in each 15-minute interval in subroutine SIGMA.
PDB	Stores DBO for plotting at end of each cruise.
PRNG	Stores RNGO for plotting at end of each cruise.
RNG1	Stores ranges for Case I.*
RNG2	Stores ranges for Case II.*

TABLE XII. (Cont'd)

RNG3	Stores ranges for Case III.*
RNG4	Stores ranges for Case IV.*
RNG	Stores ranges for Cases I and II.*
RNGO	Stores ranges for Cases III and IV.*
SLOPE 1	Stores ranges for Cases III and IV.*
SLOPE 2	Stores slopes for Case II* by station number.
SLOPE 3	Stores slopes for Case III* by station number.
SLOPE 4	Stores slopes for Case IV* by station number.
X	Stores Var(Y(t)) within five-minute intervals.
XX	Stores top and bottom of thermocline information for pairs of observations.
XRNG1	Used in plotting RNG1.
XRNG2	Used in plotting RNG2.
XRNG3	Used in plotting RNG3.
XRNG4	Used in plotting RNG4.
XRNGO	Used in plotting RNGO.
XRNG	Used in plotting RNG
XY	Used in computing Var(Y(Δt)) in subroutine SIGMA.
XZ	Var(Y(Δt)) within each 15-minute interval in subroutine SIGMA.

*Refer diagram on Page 39.

TABLE XIII.

Description of Variables

Variable	Description
IA	Set equal to the station number. Used to check for the end of a station.
IJK	Set to the cruise number under consideration. Used in finding LL.
IQ	Counter for arrays collecting data over each cruise.
JJK	May be 1 or zero. When set to zero by the program, it stops the iteration at the end of the cruise specified by NK(1).
JJL	A switching mechanism that allows computations to proceed for cruise 12 at the end of the acoustic data file.
KNT	Specifies the number of iterations within each run of the program.
KK	Cruise number.
L	Sets the transmitting frequency.
LL	Specifies the number of stations in a particular cruise.
LLL	Allows for zeroing certain variables in subroutine $COMP_1$ at the beginning of each iteration.
LX1	The BT pattern code for Ship 1 and 1st set in data pair.
LX2	The BT pattern code for Ship 2 and 1st set in data pair.
LX2	The BT pattern code for Ship 2 and 1st set in data pair.
LX3	The BT pattern code for Ship 1 and 2nd set in data pair.

TABLE XIII. (Cont'd)

Variable	Description
LX4	The BT pattern code for Ship 2 and 2nd set in data pair.
MM	Counter for the MK array.
MMM	Counter for the MMK array.
MX	Counter for arrays collecting data over all cruises.
NC	Set to the cruise number under consideraion. Used to check for the end of a cruise.
NN	Sets the station number for use with the SLOPE arrays.
SIG	Standard deviation of Y(t)
VAR	Var(Y(t))
X	Source depth
Y	Receiver depth
Z	Maximum allowable range differences between pairs of observations.

```
C
C
C
C     THE MAIN PROGRAM ESSENTIALLY CHECKS DATA AGAINST INPUT PARAMETERS
C     AND CONTROLS THE LOADING OF ARRAYS A,B,A1,B1,MK,AND MMK. ARRAYS
C     A AND B COLLECT DATA FOR EACH ITERATION WHEREAS ARRAYS A1 AND B1
C     COLLECT THE SAME DATA OVER THE ENTIRE RUN. ARRAY MK STORES DATA
C     RECORDS WHICH MEET ALL PARAMETER RESTRICTIONS OVER CRUISES. AT
C     THE END OF A CRUISE, THE MK ARRAY IS FILLED AGAIN.
C
C
C
      COMMON L,LL,X,Y,KK,MM,MMM,Z,NN,LLL,MX,JJL,IJK,IQ,IN(27),NK(35),
     1MK(300,27),MMK(100,27),A1(500),B1(500,1),SLOPE1(30),SLOPE2(30),
     2SLOPE3(30),SLOPE4(30),LLX1(2000),LLX2(2000),LLX3(2000),
     3LLX4(2000),A(500),B(500,1),IK(27)
      KNT=1
      DO 500  J=1,KNT
      READ(5,100)  (NK(I),I=1,35)
  100 FORMAT(11I6,/,3I6,5X,A1,I6,5X,A1,I6,5X,A1,I6,5X,A1,I6,/,11I6,
     1/,2I6)
      KNT=NK(35)
      WRITE(6,1500) J
 1500 FORMAT('1',/,'0',/,'0',/,'0',/,'0',56X,'***********************',
     1/,' ',56X,'*',21X,'*',/,' ',56X,'*',3X,'ITERATION NO.',I2,3X,
     2'*',/,' ',56X,'*',21X,'*',/,' ',56X,'***********************',/,
     3'0',60X,'THE INPUT ARRAY',/,'+',60X,'_______________',/,'0',
     461X,'I',8X,'NK(I)',/,'+',60X,'___',7X,'_____',/,'1')
      DO 700  I=1,14
      WRITE(6,1501)  I,NK(I)
 1501 FORMAT(' ',60X,I3,6X,I6)
  700 CONTINUE
      DO 701  I=15,21,2
      JA=I+1
      WRITE(6,1502)  I,NK(I),JA,NK(JA)
 1502 FORMAT(' ',60X,I3,11X,A1,/,' ',60X,I3,6X,I6)
  701 CONTINUE
      DO 702  I=23,35
      WRITE(6,1503)  I,NK(I)
 1503 FORMAT(' ',60X,I3,6X,I6)
  702 CONTINUE
      MX=0
      KK=NK(33)
      L=NK(24)
      LLL=1
      IQ=0
      MM=0
      MMM=0
```

```
      JJK=1
      JJL=1
      N=0
      IA=1
      DO 150 I=1,30
      SLOPE1(I)=0.0
      SLOPE2(I)=0.0
      SLOPE3(I)=0.0
      SLOPE4(I)=0.0
  150 CONTINUE
    1 IF(JJL.EQ.0) GO TO 63
      READ(9,200,END=60) (IN(I),I=1,27)
  200 FORMAT(2I2,I4,A2,4I2,I3,I1,6I3,I1,I2,I1,I2,2I2,A1,2I2,A1,I4)
C
C    SKIP THE ZERO ENTRIES IN KC COLUMN.
C
      IF(IN(L).EQ.0) GO TO 1
      IJK=IN(1)
C
C    CHECK THE CRUISE NUMBER.
C
      IF(NK(1).EQ.0) GO TO 2
      IF(NK(1).EQ.IN(1)) GO TO 2
      IF(IN(1).LT.NK(1)) GO TO 1
      IF(JJK.EQ.0) GO TO 1
      JJK=0
      CALL COMP1(&60,&1,&1)
C
C    CHECK STATION NUMBER.
C
    2 IF(NK(2).EQ.0) GO TO 3
      IF(NK(2).NE.IN(2)) GO TO 1
C    CHECK TIME
    3 IF(NK(3).EQ.0) GO TO 4
      IF(NK(3).GE.IN(3)) GO TO 1
      IF(NK(4).LE.IN(3)) GO TO 1
C
C    CHECK TIME ZONE
C
    4 IF(NK(5).EQ.0) GO TO 6
      IF(NK(5).NE.IN(4)) GO TO 1
C
C    CHECK THE MONTH
C
    6 IF(NK(6).EQ.0) GO TO 8
      IF(NK(6).GE.IN(6)) GO TO 1
      IF(NK(7).LE.IN(L)) GO TO 1
C
```

```
C     CHECK THE YEAR
C
    8 IF(NK(8).EQ.0) GO TO 9
      IF(NK(8).NE.IN(7)) GO TO 1
C
C     CHECK THE RANGE LIMITS
C
    9 IF(NK(9).EQ.0) GO TO 10
      IF(NK(9).GE.IN(9)+1000*IN(8)) GO TO 1
      IF(NK(10).LE.IN(9)+1000*IN(8)) GO TO 1
C
C     CHECK FOR THE RECEIVING SHIP.
C
   10 IF(NK(11).EQ.0) GO TO 13
      IF(NK(11).NE.IN(10)) GO TO 1
C
C     CHECK RECEIVING AND SOURCE DEPTHS.
C
   13 IF(NK(12).EQ.-1)GO TO 15
      IF((IN(11).LE.30).OR.(IN(12).LE.30)) GO TO 134
      IF((IN(11).LE.NK(12)+5).AND.(IN(11).GE.NK(12)-5)) IN(11)=NK(12)
      IF((IN(11).LE.NK(13)+5).AND.(IN(11).GE.NK(13)-5)) IN(11)=NK(13)
      IF((IN(12).LE.NK(12)+5).AND.(IN(12).GE.NK(12)-5)) IN(12)=NK(12)
      IF((IN(12).LE.NK(13)+5).AND.(IN(12).GE.NK(13)-5)) IN(12)=NK(13)
  134 IF((NK(12).EQ.IN(11)).OR.(NK(12).EQ.IN(12))) GO TO 131
      GO TO 1
  131 IF((NK(13).EQ.IN(11)).OR.(NK(13).EQ.IN(12))) GO TO 132
      GO TO 1
  132 IF(NK(12).NE.NK(13)) GO TO 133
      IF((NK(12).EQ.IN(11)).AND.(NK(13).EQ.IN(12))) GO TO 15
      GO TO 1
  133 IF(IN(11).NE.IN(12)) GO TO 15
      GO TO 1
C
C     CHECK THE LATITUDE.
C
   15 IF(NK(14).EQ.0) GO TO 16
      XLAT=IN(21)+IN(22)/60.0
      YLAT1=NK(14)/1000.0
      YLAT2=NK(16)/1000.0
      IF((IN(23).EQ.NK(15)).OR.(IN(23).EQ.NK(17))) GO TO 17
      GO TO 1
   17 IF(NK(15).NE.NK(17)) GO TO 18
      IF(XLAT.GE.YLAT1) GO TO 19
      GO TO 1
   19 IF(XLAT.LE.YLAT2) GO TO 16
      GO TO 1
   18 IF(IN(23).NE.NK(15)) GO TO 20
```

```
      IF(XLAT.LE.YLAT1) GO TO 16
      GO TO 1
   20 IF(XLAT.LE.YLAT2) GO TO 16
      GO TO 1
C
C    CHECK THE LONGITUDE.
C
   16 IF(NK(18).EQ.0) GO TO 25
      XLONG=IN(24)+IN(25)/60.0
      YLONG1=NK(18)/1000.0
      YLONG2=NK(20)/1000.0
      IF((IN(26).EQ.NK(19)).OR.(IN(26).EQ.NK(21))) GO TO 21
      GO TO 1
   21 IF(NK(19).NE.NK(21)) GO TO 22
      IF(XLONG.GE.YLONG1) GO TO 23
      GO TO 1
   23 IF(XLONG.LE.YLONG2) GO TO 25
      GO TO 1
   22 IF(IN(26).NE.NK(19)) GO TO 24
      IF(XLONG.LE.YLONG1) GO TO 25
      GO TO 1
   24 IF(XLONG.LE.YLONG2) GO TO 25
      GO TO 1
C
C    CHECK THE WATER DEPTH.
C
   25 IF(NK(22).EQ.-1) GO TO 26
      IF(NK(22).GE.IN(27)) GO TO 1
      IF(NK(23).LE.IN(27)) GO TO 1
C
C    STORE THE RECORD FOR FUTURE USE IN SUBROUTINE COMP IN EITHER
C    THE MK OR MMK ARRAY.  NOTE THAT LATER IN THE PROGRAM, THE CONTENTS
C    OF MMK ARE PUT INTO MK AT THE END OF EACH CRUISE FOR THE NEXT
C    CRUISE.
C
   26 IF(IN(1).NE.KK) GO TO 27
      MM=MM+1
      DO 300 K=1,27
      MK(MM,K)=IN(K)
  300 CONTINUE
      GO TO 401
   27 MMM=MMM+1
      DO 400 K=1,27
      MMK(MMM,K)=IN(K)
  400 CONTINUE
  401 CALL COMP1(&60,&1,&1)
   60 IF((IN(1).EQ.12).AND.(JJL.EQ.1)) GO TO 61
   63 CONTINUE
```

```
 64 CALL SIGMA(A,B,IQ)
    IF(NK(35).EQ.1) GO TO 62
    CALL SIGMA(A1,B1,MX)
    GO TO 62
 61 JJL=0
    CALL COMP1(&60,&1,&1)
 62 CALL BTLAYR
    REWIND 9
500 CONTINUE
    STOP
    END

    SUBROUTINE COMP1(*,*)
C
C
C
C  SEPARATES THE DATA COMING FROM THE MAIN PPROGRAM INTO CATEGORIES
C  BY SOURCE/RECEIVER DEPTHS AND RANGES BELOW AND ABOVE 5000 YDS.
C  (THERE WILL BE 4 POSSIBLE COMBINATIONS). THE SUBROUTINE POOLS
C  THIS INFORMATION BY STATIONS AND COMPUTES THE SLOPES,AVERAGE
C  RANGE, AND X-AXIS INTERCEPT FOR EACH OF THESE CASES. AT THE END
C  OF EACH CRUISE, THE SLOPE INFORMATION IS PASSED TO SUBROUTINE COMP
C  (THROUGH COMMON) FOR FURTHER COMPUTATIONS.
C
C
C
    COMMON L,LL,X,Y,KK,MM,MMM,Z,NN,LLL,MX,JJL,IJK,IQ,IN(27),NK(35),
   1MK(300,27),MMK(100,27),A1(500),B1(500,1),SLOPE1(30),SLOPE2(30),
   2SLOPE3(30),SLOPE4(30),LLX1(2000),LLX2(2000),LLX3(2000),
   3LLX4(2000),A(500),B(500,1),IK(27)
    DIMENSION DB1(50),DB2(50),DB3(50),DB4(50),DB(100),DB0(100),
   1PDB(100),RNG1(50,1),RNG2(50,1),RNG3(50,1),RNG4(50,1),RNG(100,1),
   2RNG0(100,1),PRNG(100,1),XRNG1(50),XRNG2(50),XRNG3(50),XRNG4(50),
   3XRNG(100),XRNG0(100)
    IF(LLL.NE.1) GO TO 9
    KK=IN(1)
    LL=NK(IJK+20)
    IPLOT=1
    LLL=0
    N1=0
    N2=0
    K1=0
    K2=0
    M1=0
    M2=0
    IA=1
    X=NK(12)
```

```
      Y=NK(13)
      NN=0
      Z=NK(26)*1.0
      NC=IN(1)
    9 IF(IN(2).NE.IA) GO TO 1000
      IF(JJL.EQ.0) GO TO 1000
   10 NN=IN(2)
      KK=IN(1)
C
C     CHECK SOURCE/RECEIVER DEPTH  CATEGORY.
C
      IF((IN(11).EQ.X).AND.(IN(12).EQ.Y)) GO TO 4
      IF((IN(11).EQ.Y).AND.(IN(12).EQ.X)) GO TO 5
      NC=IN(1)
      GO TO 300
C
C     SEPARATE RECORDS ACCORDING TO ABOVE OR BELOW 5000 YDS.
C
    4 IF(IN(9)+1000*IN(8).GT.NK(34)) GO TO 41
      N1=N1+1
      RNG1(N1,1)=IN(9)+1000*IN(8)
      XRNG1(N1)=RNG1(N1,1)
      DB1(N1)=IN(L)/3.0
      GO TO 6
   41 N2=N2+1
      RNG2(N2,1)=IN(9)+1000*IN(8)
      XRNG2(N2)=RNG2(N2,1)
      DB2(N2)=IN(L)/3.0
      GO TO 61
C
C     SEPARATE RECORDS ACCORDING TO ABOVE OR BELOW 5000 YDS.
C
    5 IF(IN(9)+1000*IN(8).GT.NK(34)) GO TO 51
      K1=K1+1
      RNG3(K1,1)=IN(9)+1000*IN(8)
      XRNG3(K1)=RNG3(K1,1)
      DB3(K1)=IN(L)/3.0
      GO TO 7
   51 K2=K2+1
      RNG4(K2,1)=IN(9)+1000*IN(8)
      XRNG4(K2)=RNG4(K2,1)
      DB4(K2)=IN(L)/3.0
      GO TO 71
    6 M1=M1+1
      RNG(M1,1)=RNG1(N1,1)
      XRNG(M1)=RNG(M1,1)
      DB(M1)=DB1(N1)
      GO TO 8
```

```
   61 M1=M1+1
      RNG(M1,1)=RNG2(N2,1)
      XRNG(M1)=RNG(M1,1)
      DB(M1)=DB2(N2)
      GO TO 8
    7 M2=M2+1
      RNGO(M2,1)=RNG3(K1,1)
      XRNGO(M2)=RNGO(M2,1)
      DBO(M2)=DB3(K1)
      GO TO 8
   71 M2=M2+1
      RNGO(M2,1)=RNG4(K2,1)
      XRNGO(M2)=RNGO(M2,1)
      DBO(M2)=DB4(K2)
    8 WRITE(6,3) (IN(I),I=1,27)
    3 FORMAT('0',2I2,I4,A2,4I2,I3,I1,6I3,I1,I2,I1,I2,2I2,A1,2I2,A1,I4)
  300 IF(IA) 200,201,202
  200 RETURN
  201 RETURN 1
  202 RETURN 2
 1000 WRITE(6,20)
   20 FORMAT('0','END OF DATA FILE')
      IF((MM.EQ.1).AND.(MMM.EQ.1)) GO TO 18
      C1=0.0
      C2=150.0
      C3=500.0
      C4=30000
      IX=1
C
C     SET THE VALUES OF THE SLOPES THAT HAVE ONLY ONE DATA POINT. NOTE
C     THE SPECIAL SLOPE TREATMENT FOR CRUISES 5 AND 11.
C
      IF(N1.EQ.1) SLOPE1(NN)=.0045
      IF(KK.EQ.11) SLOPE1(NN)=.01
      IF(KK.EQ.5) SLOPE1(NN)=.028
      IF(N1.EQ.0) SLOPE1(NN)=0.0
      IF(N2.EQ.1) SLOPE2(NN)=.0015
      IF(K1.EQ.1) SLOPE3(NN)=.0045
      IF(KK.EQ.11) SLOPE3(NN)=.01
      IF(KK.EQ.5) SLOPE3(NN)=.028
      IF(K1.EQ.0) SLOPE3(NN)=0.0
      IF(K2.EQ.1) SLOPE4(NN)=.0015
      IF(N1.LT.2) GO TO 11
C
C     COMPUTE THE SLOPES FOR ALL CASES WHERE THERE ARE TWO OR MORE
C     DATA POINTS.
C
      WRITE(6,1002)
```

```
1002 FORMAT('0','SLOPE1 CASE',/,'+','___________')
     CALL RGRESS(DB1,XRNG1,N1,SLOPE)
     SLOPE1(NN)=SLOPE
  11 IF(N2.LT.2) GO TO 12
     WRITE(6,1003)
1003 FORMAT('0','SLOPE2 CASE',/,'+','___________')
     CALL RGRESS(DB2,XRNG2,N2,SLOPE)
     SLOPE2(NN)=SLOPE
  12 IF(K1.LT.2) GO TO 13
     WRITE(6,1004)
1004 FORMAT('0','SLOPE3 CASE',/,'+','___________')
     CALL RGRESS(DB3,XRNG3,K1,SLOPE)
     SLOPE3(NN)=SLOPE
  13 IF(K2.LT.2) GO TO 14
     WRITE(6,1005)
1005 FORMAT('0','SLOPE4 CASE',/,'+','___________')
     CALL RGRESS(DB4,XRNG4,K2,SLOPE)
     SLOPE4(NN)=SLOPE
  14 IA=IN(2)
     IF(M1.EQ.0) GO TO 16
  15 DO 500 IP=1,M1
     PDB(IP)=DB(IP)
     PRNG(IP,1)=RNG(IP,1)
 500 CONTINUE
  16 IF(M2.EQ.0) GO TO 601
     DO 600 IP=1,M2
     IPP=IP+M1
     PDB(IPP)=DBO(IP)
     PRNG(IPP,1)=RNGO(IP,1)
 600 CONTINUE
C
C    PLOTS TRANSMITTING RANGE VS. TRANSMISSION LOSS FOR EACH STATION
C    AT THE USERS OPTION. IF 'IPLOT' EQUALS ANY NUMBER EXCEPT 1, THEN
C    THE GRAPH IS PLOTTED.
C
 601 IF(IPLOT.EQ.1) GO TO 17
     CALL OSPLOT(PDB,PRNG,IPP,500,1,IX,C1,C2,C3,C4)
     WRITE(6,1001)
1001 FORMAT('0',30X,'RANGE(K-YDS) VS. CHANGE IN DECIBEL LOSS',/,'+',
    1'____________',5X,'______________________')
  17 N1=0
     N2=0
     K1=0
     K2=0
     M1=0
     M2=0
     IF(JJL.EQ.0) GO TO 3000
     IF((IA.GT.LL).OR.(NC.NE.IN(1))) GO TO 3000
```

```
      GO TO 10
 3000 WRITE(6,40)
   40 FORMAT('1','STATION',6X,'SLOPE1',6X,'SLOPE2',6X,'SLOPE3',6X,
     1'SLOPE4')
      DO 700 K=1,NN
      WRITE(6,45) K,SLOPE1(K),SLOPE2(K),SLOPE3(K),SLOPE4(K)
   45 FORMAT(' ',2X,I2,7X,F10.8,4X,F10.8,4X,F10.8,4X,F10.8)
  700 CONTINUE
      CALL COMP
   18 LL=NK(IJK+20)
      NN=IN(2)
      IA=1
      N1=0
      N2=0
      K1=0
      K2=0
      M1=0
      M2=0
C
C   SPECIAL RETURN WHEN CONSIDERING ONLY ONE CRUISE.
C
      IF(KK.EQ.NK(1)) RETURN 1
      NC=IN(1)
      KK=IN(1)
      WRITE(6,1006) KK,NC
 1006 FORMAT('0','COMP1 KK=',I3,'NC=',I3)
      DO 100 I=2,30
      SLOPE1(I)=0.0
      SLOPE2(I)=0.0
      SLOPE3(I)=0.0
      SLOPE4(I)=0.0
  100 CONTINUE
      GO TO 10
      END


      SUBROUTINE COMP
C
C
C
C   COMPUTES THE CHANGE IN DECIBEL LOSS IN A SEQUENTIAL MANNER.  IF
C   TWO RECORDS ARE SEPARATED BY NO MORE THAN 'Z' YDS, THEN COMPUTATION
C   PROCEEDS. OF THE TWO RECORDS BEING CONSIDERED AT SOME PARTICULAR
C   TIME, THE DECIBEL LOSS OF THE SECOND RECORD IS ADJUSTED WITH
C   RESPECT TO THE DIFFERENCE IN RANGE ASSOCIATED WITH THE TWO RECORDS.
C   THE CHANGE IN DECIBELL LOSS IS THEN COMPUTED AND PLOTTED VS.THE
C   CHANGE IN TIME BETWEEN THE TWO RECORDS.
C
```

```
C
C
      COMMON L,LL,X,Y,KK,MM,MMM,Z,NN,LLL,MX,JJL,IJK,IQ,IN(27),NK(35),
     1MK(300,27),MMK(100,27),A1(500),B1(500,1),SLOPE1(30),SLOPE2(30),
     2SLOPE3(30),SLOPE4(30),LLX1(2000),LLX2(2000),LLX3(2000),
     3LLX4(2000),A(500),B(500,1),IK(27)
      IS=1
      C1=0.0
      C2=120.0
      C3=-20.0
      C4=20.0
      N=0
      JJ=1
      DO 100 I=1,27
      IK(I)=MK(JJ,I)
  100 CONTINUE
      WRITE(6,1) (IK(I),I=1,27)
    1 FORMAT('0',2I2,I4,A2,4I2,I3,I1,6I3,I1,I2,I1,I2,2I2,A1,2I2,A1,I4)
C
C    PULL OUT ESSENTIAL DATA FROM THE FIRST RECORD.
C
      LX1=IK(18)
      LX2=IK(20)
      ICRU1=IK(1)
      ISTA1=IK(2)
      DEPTH1=IK(11)
      TIME1=IK(3)
      RNG1=IK(9)+1000*IK(8)
      AVDB1=IK(L)/3.0
    4 JJ=JJ+1
      DO 200 I=1,27
      IK(I)=MK(JJ,I)
  200 CONTINUE
      WRITE(6,2) (IK(I),I=1,27)
    2 FORMAT('0',2I2,I4,A2,4I2,I3,I1,6I3,I1,I2,I1,I2,2I2,A1,2I2,A1,I4)
C
C    PULL OUT ESSENTIAL DATA FOR ALL RECORDS EXCEPT THE FIRST.
C
      LX3=IK(18)
      LX4=IK(20)
      ICRU2=IK(1)
      ISTA2=IK(2)
      DEPTH2=IK(11)
      TIME2=IK(3)
      RNG2=IK(9)+1000*IK(8)
      AVDB2=IK(L)/3.0
      IF(ISTA1.NE.ISTA2) GO TO 5
      IF(DEPTH1.EQ.DEPTH2) GO TO 5
```

```
      DELRNG=ABS(RNG2-RNG1)
      IF(DELRNG.GT.Z) GO TO 5
      CALL TIMDIF(TIME1,TIME2,T)
      DELTIM=T
      IF((IK(11).EQ.X).AND.(IK(12).EQ.Y)) GO TO 9
      IF((IK(11).EQ.Y).AND.(IK(12).EQ.X)) GO TO 10
    9 IF((RNG1.GT.NK(34)).AND.(RNG2.GT.NK(34))) GO TO 92
      IF((RNG1.LE.NK(34)).AND.(RNG2.LE.NK(34))) GO TO 93
C
C    COMPUTE THE ADJUSTED CHANGE IN TRANSMISSION LOSS.
C
      AVDB1=AVDB1+SLOPE1(ISTA1)*(5000-RNG1)
      AVDB2=AVDB2-SLOPE2(ISTA1)*(RNG2-5000)
      AVDB=AVDB2-AVDB1
      GO TO 12
   92 AVDB2=AVDB2-SLOPE2(ISTA1)*(RNG2-RNG1)
      AVDB=AVDB2-AVDB1
      GO TO 12
   93 AVDB2=AVDB2-SLOPE1(ISTA1)*(RNG2-RNG1)
      AVDB=AVDB2-AVDB1
      GO TO 12
   10 IF((RNG1.GT.NK(34)).AND.(RNG2.GT.NK(34))) GO TO 102
      IF((RNG1.LE.NK(34)).AND.(RNG2.LE.NK(34))) GO TO 103
      AVDB1=AVDB1+SLOPE3(ISTA1)*(5000.0-RNG1)
      AVDB2=AVDB2-SLOPE4(ISTA1)*(RNG2-5000.0)
      AVDB=AVDB2-AVDB1
      GO TO 12
  102 AVDB2=AVDB2-SLOPE4(ISTA1)*(RNG2-RNG1)
      AVDB=AVDB2-AVDB1
      GO TO 12
  103 AVDB2=AVDB2-SLOPE3(ISTA1)*(RNG2-RNG1)
      AVDB=AVDB2-AVDB1
   12 MX=MX+1
      WRITE(6,1001) MX
 1001 FORMAT('0',2X,'MX =',I8)
C
C    LOAD BT PATTERN CODE INTO ARRAYS FOR USE IN SUBROUTINE BTLAYR.
C
      LLX1(MX)=LX1
      LLX2(MX)=LX2
      LLX3(MX)=LX3
      LLX4(MX)=LX4
      WRITE(6,60) ISTA1,TIME1,TIME2,DELTIM,RNG1,RNG2,DELRNG,AVDB1,AVDB2
     1,AVDB
   60 FORMAT('0',2X,I4,9F10.3)
      N=N+1
      IQ=IQ+1
      A(IQ)=DELTIM
```

```
      A1(MX)=DELTIM
      B(IQ,1)=AVDB
      B1(MX,1)=AVDB
C
C    RESET APPROPRIATE DATA VARIABLES IF UNABLE TO COMPUTE ADJUSTED
C    CHANGE IN TRANSMISSION LOSS.
C
    5 AVDB1=AVDB2
      ICRU1=ICRU2
      ISTA1=ISTA2
      TIME1=TIME2
      RNG1=RNG2
      DEPTH1=DEPTH2
      LX1=LX3
      LX2=LX4
      IF(JJ.GE.MM) GO TO 3000
      GO TO 4
 3000 IF(N.EQ.0) GO TO 18
   18 IF(MMM.EQ.0) GO TO 17
      DO 300 J=1,MMM
      DO 400 K=1,27
      MK(J,K)=MMK(J,K)
  400 CONTINUE
      WRITE(6,1004) (MK(J,K),K=1,27)
 1004 FORMAT('0',2I2,I4,A2,4I2,I3,I1,6I3,I1,I2,I1,I2,2I2,A1,2I2,A1,I4)
  3C0 CONTINUE
   17 MM=MMM
      WRITE(6,1005) MM,KK
 1005 FORMAT('0','COMP MM=',I3,'KK=',I3)
      MMM=0
      RETURN
      END


      SUBROUTINE SIGMA(AA,BB,MZ)
C
C
C
C    DIVIDES THE CHANGE IN DECIBEL LOSSES WITH RESPECT TO TIME INTO
C    FIVE MINUTE INTERVALS,COMPUTES THE VARIANCE WITHIN EACH INTERVAL
C    AND PLOTS VARIANCE VS. CHANGE IN TIME. THE SAME COMPUTATIONS ARE
C    DONE FOR 15 MINUTE INTERVALS BUT ARE NOT PLOTTED.
C
C
C
C
      REAL J
      DIMENSION X(25,1),N(25),J(25),AA(500),BB(5C0,1),XY(25),NY(25),
     1XZ(25)
```

```
      II=0
      DO 50 I=1,25
      XY(I)=0.0
      NY(I)=0
      XZ(I)=0.0
      X(I,1)=0.0
      N(I)=0
   50 CONTINUE
      WRITE(6,4)
    4 FORMAT('1',1X,'INTERVAL',2X,'VARIANCE',4X,'COUNT',/,'+',1X,'____
     1____',2X,'________',4X,'_____')
      M=0
      Y=0.0
      K=0
      DO 100 JJ=5,125,5
      K=K+1
      DO 200 I=1,MZ
      IF((AA(I).LT.JJ-5).OR.(AA(I).GE.JJ)) GO TO 200
      X(K,1)=X(K,1)+(ABS(BB(I,1)))**2
      N(K)=N(K)+1
  200 CONTINUE
  100 CONTINUE
      DO 300 L=1,K
      IF((X(L,1).EQ.0.0).OR.(N(L).EQ.0)) GO TO 300
      X(L,1)=X(L,1)/N(L)
  300 CONTINUE
      DO 500 KK=1,K
      XK=5*KK
      WRITE(6,2) XK,X(KK,1),N(KK)
    2 FORMAT(4X,F4.1,4X,F8.3,4X,I3)
  500 CONTINUE
      DO 600 KNT=1,K
      Y=Y+X(KNT,1)*N(KNT)
      M=M+N(KNT)
  600 CONTINUE
      VAR=Y/M
      SIG=SQRT(VAR)
      WRITE(6,3) VAR,SIG,M
    3 FORMAT('0','VARIANCE=',F10.3,'SIGMA =',F7.3,'SAMPLE SIZE =',I4)
      DO 800 LL=1,8
      DO 700 III=1,3
      II=II+1
      XY(LL)=XY(LL)+X(II,1)*N(II)
      NY(LL)=NY(LL)+N(II)
  700 CONTINUE
  800 CONTINUE
      DO 900 LL=1,8
      IF((XY(LL).EQ.0.0).OR.(NY(LL).EQ.0)) GO TO 901
```

```
      XZ(LL)=XY(LL)/NY(LL)
  901 KY=15*LL
      WRITE(6,5) KY,XZ(LL),NY(LL)
    5 FORMAT('0',2X,I3,2X,F8.3,2X,I6)
  900 CONTINUE
      DO 400 I=1,K
      J(I)=5*I-2.5
  400 CONTINUE
      CALL OSPLOT(J,X,K,50,1,1,0.0,130.0,0.0,400.0)
      RETURN
      END

      SUBROUTINE BTLAYR
C
C
C
C   SEPARATES THOSE RECORDS WHICH HAVE BEEN COMPARED BY SUBROUTINE
C   COMP INTO THREE CATEGORIES -- ABOVE THE BT LAYER,BELOW THE BT LAYER
C   ALL OTHER COMBINATIONS. THE SUBROUTINE THEN PLOTS CHANGE IN DB LOSS
C   VS. CHANGE IN TIME, AND VARIATION OF DB LOSS VS. CHANGE IN TIME.
C
C   AN AVERAGE IS TAKEN OF FIRST, THE TOP OF THE LAYER, AND THEN
C   THE BOTTOM OF THE LAYER OVER THE TWO RECORDS BEING COMPARED.
C   THE MINIMUM TOP LAYER AND THE MAXIMUM BOTTOM LAYER FIGURES ARE
C   THEN USED TO DETERMINE WITHIN WHICH CATEGORY THE COMPARISON FALLS.
C
C
C
      COMMON L,LL,X,Y,KK,MM,MMM,Z,NN,LLL,MX,JJL,IJK,IQ,IN(27),NK(35),
     1MK(300,27),MMK(100,27),A1(500),B1(500,1),SLOPE1(30),SLOPE2(30),
     2SLOPE3(30),SLOPE4(30),LLX1(2000),LLX2(2000),LLX3(2000),
     3LLX4(2000),A(500),B(500,1),IK(27)
      DIMENSION IDB(4,2),XX(4,2),AT(400),BT(400,1),AU(400),BU(400,1),
     1AV(400),BV(400,1)
      ILOT=1
      IT=0
      IU=0
      IV=0
      NX=0
   20 NX=NX+1
      IF(LLX1(NX).LE.10) LLX1(NX)=LLX2(NX)
      IF(LLX2(NX).LE.10) LLX2(NX)=LLX1(NX)
      IF(LLX3(NX).LE.10) LLX3(NX)=LLX4(NX)
      IF(LLX4(NX).LE.10) LLX4(NX)=LLX3(NX)
      IDB(1,1)=LLX1(NX)/10.0
      IDB(1,2)=LLX1(NX)-10*IDB(1,1)
      IDB(2,1)=LLX2(NX)/10.0
```

```
      IDB(2,2)=LLX2(NX)-10*IDB(2,1)
      IDB(3,1)=LLX3(NX)/10.0
      IDB(3,2)=LLX3(NX)-10*IDB(3,1)
      IDB(4,1)=LLX4(NX)/10.0
      IDB(4,2)=LLX4(NX)-10*IDB(4,1)
      DO 100 I=1,4
      N=IDB(I,1)
      GO TO(1,1,4,1,2,2,3,4),N
    1 XX(I,1)=0.0
      GO TO 100
    2 XX(I,1)=30.0
      GO TO 100
    3 XX(I,1)=50.0
      GO TO 100
    4 N=IDB(I,2)
      GO TO(5,5,5,5,6,6,7,8),N
    5 XX(I,1)=100.0
      GO TO 100
    6 XX(I,1)=150.0
      GO TO 100
    7 XX(I,1)=200.0
      GO TO 100
    8 XX(I,1)=600.0
  100 CONTINUE
      DO 200 I=1,4
      N=IDB(I,2)
      GO TO(9,10,11,9,9,9,9,12),N
    9 XX(I,2)=300.0
      GO TO 200
   10 XX(I,2)=200.0
      GO TO 200
   11 XX(I,2)=150.0
      GO TO 200
   12 N=IDB(I,1)
      GO TO(13,14,15,13,14,13,13,50),N
   13 XX(I,2)=100.0
      GO TO 200
   14 XX(I,2)=50.0
      GO TO 200
   15 XX(I,2)=30.0
      GO TO 200
   50 XX(I,2)=600.0
  200 CONTINUE
      Y1=(XX(1,1)+XX(3,1))/2.0
      Y2=(XX(2,1)+XX(4,1))/2.0
      YY1=(XX(1,2)+XX(3,2))/2.0
      YY2=(XX(2,2)+XX(4,2))/2.0
      IF(Y1.LT.Y2) GO TO 30
```

```
      Z1=Y2
      GO TO 31
   30 Z1=Y1
   31 IF(YY1.LT.YY2) GO TO 32
      Z2=YY1
      GO TO 33
   32 Z2=YY2
   33 WRITE(6,1001) NX,Z1,Z2
 1001 FORMAT('0',I3,2F8.2)
      IF((X.LE.Z1).AND.(Y.LE.Z1)) GO TO 16
      IF((X.GE.Z2).AND.(Y.GE.Z2)) GO TO 17
C
C    STORE COMBINED DATA.
C
      IT=IT+1
      AT(IT)=A1(NX)
      BT(IT,1)=B1(NX,1)
      GO TO 18
C
C    STORE DATA ABOVE THE LAYER.
C
   16 IU=IU+1
      AU(IU)=A1(NX)
      BU(IU,1)=B1(NX,1)
      GO TO 18
C
C    STORE DATA BELOW THE LAYER.
C
   17 IV=IV+1
      AV(IV)=A1(NX)
      BV(IV,1)=B1(NX,1)
   18 IF(NX.LT.MX) GO TO 20
      C1=0.0
      C2=120.0
      C3=-20.0
      C4=20.0
C
C    PLOT CHANGE IN TRANSMISSION LOSS VS. TIME AT USERS OPTION.
C
      IF(ILOT.EQ.1) GO TO 2033
      CALL OSPLOT(AT,BT,IT,200,1,1,C1,C2,C3,C4)
      CALL OSPLOT(AU,BU,IU,200,1,1,C1,C2,C3,C4)
      CALL OSPLOT(AV,BV,IV,200,1,1,C1,C2,C3,C4)
 2033 CALL SIGMA(AT,BT,IT)
      CALL SIGMA(AU,BU,IU)
      CALL SIGMA(AV,BV,IV)
      RETURN
      END
```

```
C
C
C
C     SOLVES SIMULTANEOUS LINEAR EQUATIONS. COMPUTES SLOPES AND
C     INTERCEPTS.
C
C
C
C

      SUBROUTINE SIME(A,B,N,KS)                                         SUB00460
      DIMENSION A(9),B(3)                                               SUB00470
      TOL=0.0                                                           SUB00480
      KS=0                                                              SUB00490
      JJ=-N                                                             SUB00500
      DO 65  J=1,N                                                      SUB00510
      JY=J+1                                                            SUB00520
      JJ=JJ+N+1                                                         SUB00530
      BIGA=0                                                            SUB00540
      IT=JJ-J                                                           SUB00550
      DO 30  I=J,N                                                      SUB00560
      IJ=IT+I                                                           SUB00570
   19 IF (ABS(BIGA)-ABS(A(IJ)))  20,30,30                               SUB00580
   20 BIGA=A(IJ)                                                        SUB00590
      IMAX=I                                                            SUB00600
   30 CONTINUE                                                          SUB00610
      IF(ABS(BIGA)-TOL) 35,35,40                                        SUB00620
   35 KS=1                                                              SUB00630
      RETURN                                                            SUB00640
   40 I1=J+N*(J-2)                                                      SUB00650
      IT=IMAX-J                                                         SUB00660
      DO 50  K=J,N                                                      SUB00670
      I1=I1+N                                                           SUB00680
      I2=I1+IT                                                          SUB00690
   42 SAVE=A(I1)                                                        SUB00700
      A(I1)=A(I2)                                                       SUB00710
      A(I2)=SAVE                                                        SUB00720
   50 A(I1)=A(I1)/BIGA                                                  SUB00730
      SAVE=B(IMAX)                                                      SUB00740
      B(IMAX)=B(J)                                                      SUB00750
      B(J)=SAVE/BIGA                                                    SUB00760
      IF(J-N) 55,70,55                                                  SUB00770
   55 IQS=N*(J-1)                                                       SUB00780
      DO 65  IX=JY,N                                                    SUB00790
      IXJ=IQS+IX                                                        SUB00800
      IT=J-IX                                                           SUB00810
      DO 60  JX=JY,N                                                    SUB00820
      IXJX=N*(JX-1)+IX                                                  SUB00830
```

```
      JJX=IXJX+IT
   60 A(IXJX)=A(IXJX)-(A(IXJ)*A(JJX))
   65 B(IX)=B(IX)-(B(J)*A(IXJ))
   70 NY=N-1
      IT=N*N
      DO 80 J=1,NY
      IA=IT-J
      IB=N-J
      IC=N
      DO 80 K=1,J
   71 B(IB)=B(IB)-A(IA)*B(IC)
      IA=IA-N
   80 IC=IC-1
      RETURN
      END
C
C
C
C     COMPUTES TIME DIFFERENCES BASED ON 0001-2400 TIME SCALE.
C
C
C

      SUBROUTINE TIMDIF(TIME1,TIME2,T)
      IF(TIME1.GT.TIME2) GO TO 1
      LAT=TIME1/100.0
      BT=TIME1-100.0*LAT
      LXT=TIME2/100.0
      YT=TIME2-100.0*LXT
      T=60.0*(LXT-LAT)+YT-BT
      GO TO 3
    1 LAT=TIME1/100.0
      BT=TIME1-100.0*LAT
      LXT=TIME2/100.0
      YT=TIME2-100.0*LXT
      IF(BT.GT.YT) GO TO 2
      CT=2400.0+YT
      DCT=CT-TIME1
      IDCT=DCT/100.0
      XDCT=DCT-100.0*IDCT
      T=60.0*IDCT+XDCT
      GO TO 3
    2 CT=60.0+YT
      DCT=CT-BT
      IDCT=LXT+23-LAT
      T=60.0*IDCT+DCT
    3 RETURN
```

```
      END

      SUBROUTINE RGRESS(X,Y,K,SLOPE)
      DIMENSION X(500),Y(500),A(4),B(2)
      Q=K/1.0
      XBAR=0.0
      YBAR=0.0
      XYB=0.0
      X2B=0.0
      Y2B=0.0
      SX2=0.0
      SY2=0.0
      SXY=0.0
      DO 1000 I=1,K
      XBAR=XBAR+X(I)/Q
      YBAR=YBAR+Y(I)/Q
      XYB=XYB+X(I)*Y(I)/Q
      X2B=X2B+(X(I)**2)/Q
      Y2B=Y2B+(Y(I)**2)/Q
 1000 CONTINUE
      DO 2000 I=1,K
      SX2=SX2+((X(I)-XBAR)**2)/(Q-1)
      SX=SQRT(SX2)
      SY2=SY2+((Y(I)-YBAR)**2)/(Q-1)
      SY=SQRT(SY2)
      SXY=SXY+((X(I)-XBAR)*(Y(I)-YBAR)/(Q-1))
 2000 CONTINUE
      WRITE(6,1001) XBAR,YBAR
 1001 FORMAT('0','AVERAGE DB LOSS =',F10.3,/,'0','AVERAGE RNG =',F10.3)
       A(1)=1.0
      A(2)=YBAR
      A(3)=YBAR
      A(4)=Y2B
      B(1)=XBAR
      B(2)=XYB
      CALL SIME(A,B,2,0)
      SLOPE=B(2)
      WRITE(6,1002) B
 1002 FORMAT('0','THE INTERCEPT =',F10.3,/,'0','THE SLOPE=',F10.7)
      RETURN
      END
C        A. IDENTIFICATION:                                            PR000760
C           TITLE:                GENERAL PURPOSE PLOTTING             PR000770
C           SUBROUTINE NAME:      OSPLOT (J5-NPGS-OSPLOT)              PR000780
C           DATE:                 IMPLEMENTED IN FEB., 1969            PR000790
C           PROGRAMMER:           ROY JOHNSON                          PR000800
C                                                                      PR000810
```

```
C                                                                      PRO00820

      SUBROUTINE OSPLOT(X,Y,N,NDIM,NCUR,ISCALE,XL,XH,YL,YH)            PRO01210
      DIMENSION XS(11),YS(17),X(1),Y(NDIM,NCUR)                        PRO01340
      INTEGER *2 IGRID(101)                                            PRO01350
      INTEGER *4 ICHAR(6)/'  + ','  * ','  $ ','  = ','  . ','    '/  PRO01360
      IF(ISCALE.EQ.1)GO TO 32                                          PRO01370
C                                                                      PRO01380
C   AUTOSCALING IF SO DESIRED.                                         PRO01390
      XMAX=-1.0E 20                                                    PRO01400
      XMIN=-XMAX                                                       PRO01410
      YMAX=XMAX                                                        PRO01420
      YMIN=-XMAX                                                       PRO01430
      DO 25 I=1,N                                                      PRO01440
      IF(X(I).GT.XMAX)XMAX=X(I)                                        PRO01450
      IF(X(I).LT.XMIN)XMIN=X(I)                                        PRO01460
   25 CONTINUE                                                         PRO01470
      DO 31 J=1,NCUR                                                   PRO01480
      DO 31 I=1,N                                                      PRO01490
      IF(Y(I,J).GT.YMAX)YMAX=Y(I,J)                                    PRO01500
      IF(Y(I,J).LT.YMIN)YMIN=Y(I,J)                                    PRO01510
   31 CCNTINUE                                                         PRO01520
      GO TO 34                                                         PRO01530
C                                                                      PRO01540
C   AUTOSCALING NOT DESIRED, USE VALUES PROVIDED                       PRO01550
   32 XMIN=XL                                                          PRO01560
      XMAX=XH                                                          PRO01570
      YMIN=YL                                                          PRO01580
      YMAX=YH                                                          PRO01590
C                                                                      PRO01600
C   GET RANGES.                                                        PRO01610
   34 XR=XMAX-XMIN                                                     PRO01620
      IF(XR.EQ.0.0)XR=1.0E-20                                          PRO01630
      YR=YMAX-YMIN                                                     PRO01640
      IF(YR.EQ.0.0)YR=1.0E-20                                          PRO01650
C                                                                      PRO01660
C   DETERMINE WHETHER OR NOT BOTH POSITIVE AND NEGATIVE VALUES OCCUR IN PRO01670
C   REPECTIVELY X AND Y.  IF THIS OCCURS, PLACE AXIS APPROPRIATELY.    PRO01680
      XT=XMAX*XMIN                                                     PRO01690
      YT=YMIN*YMAX                                                     PRO01700
      IF(XT.LT.0.0)IYAX=100.0*(-XMIN)/XR+1.5                           PRO01710
      IF(YT.LT.0.0)IXAX=64.0*YMAX/YR+1.5                               PRO01720
C                                                                      PRO01730
C   GET GRID ELEMENT DIMENSIONS.                                       PRO01740
      XINCR=XR/10.0                                                    PRO01750
      YINCR=YR/16.0                                                    PRO01760
C                                                                      PRO01770
```

```
C   STORE LABELS.
      XS(1)=XMIN
      YS(1)=YMAX
      DO 46 I=2,11
   46 XS(I)=XS(I-1)+XINCR
      DO 47 I=2,17
   47 YS(I)=YS(I-1)-YINCR
C
C   WRITE X LABELS.
      WRITE(6,10)(XS(I),I=1,11)
      II=1
      KK=0
      DO 146 LINE=1,65
C
C   SET LINE TO BLANKS.
      DO 101 J=1,101
  101 IGRID(J)=ICHAR(6)
      IF(YT.GE.0.0)GO TO 109
      IF(LINE-IXAX)109,104,109
C
C   IF LINE IS X-AXIS, THEN SET LINE TO PERIODS.
  104 DO 105 J=1,101
  105 IGRID(J)=ICHAR(5)
C
C   IF X HAS POSITIVE AND NEGATIVE VALUES, SET Y-AXIS ELEMENT OF LINE TO
C   PERIOD.
  109 IF(XT.LT.0.0)IGRID(IYAX)=ICHAR(5)
C
C   FIND Y VALUES ON THE LINE AND PLACE THE CHARACTER CORRESPONDING TO
C   THE APPROPRIATE POINT SET IN THAT X VALUE LOCATION IN LINE.
      DO 125 J=1,NCUR
      DO 125 I=1,N
      IPTY=64.0*(YMAX-Y(I,J))/YR+1.5
      IF(IPTY.GT.65)IPTY=65
      IF(IPTY.LT.1)IPTY=1
      IF(IPTY-LINE)125,117,125
  117 IPTX=100.0*(X(I)-XMIN)/XR+1.5
      JC=MOD(J,4)
      IF(JC)119,118,119
  118 IGRID(IPTX)=ICHAR(4)
      GO TO 125
  119 IGRID(IPTX)=ICHAR(JC)
  125 CONTINUE
C
C   PRINT LINE WITH OR WITHOUT LABELS, DEPENDING ON WHETHER OR NOT THEY
C   BELONG THERE.
      IF(KK)133,133,134
  133 WRITE(6,20)YS(II),(IGRID(I),I=1,101),YS(II)
```

```
      II=II+1
      GO TO 135
  134 WRITE(6,30)(IGRID(I),I=1,101)
  135 KK=KK+1
      IF(KK-4)146,136,146
  136 KK=0
  146 CONTINUE
C
C  WRITE X LABELS.
      WRITE(6,40)(XS(I),I=1,11)
      RETURN
   10 FORMAT(1H1,1PE15.2,10E10.2/10X,1H*,20(5H+****),2H+*)
   20 FORMAT(1PE10.2,1H+,101A1,1H+,E9.2)
   30 FORMAT(10X,1H*,101A1,1H*)
   40 FORMAT(10X,1H*,20(5H+****),2H+*/1PE16.2,10E10.2)
      END
```

LIST OF REFERENCES

1. Jenkins, G. M. and Watts, D. T., Spectral Analysis and its Applications, p. 1-6, Holden-Day, 1968.

2. Siegel, Sidney, Nonparametric Statistics for the Behavioral Sciences, p. 47-51, McGraw-Hill, 1956.

3. Urick, R. J., Principles of Underwater Sound for Engineers, McGraw-Hill, 1967.

4. U. S. Navy Underwater Sound Laboratory Technical Memorandum No. 2070-197168, Contents of AMOS Data Tapes, by G. S. Egeland, 21 June 1968.

5. U. S. Navy Underwater Sound Laboratory Report No. 255, Report on the Status of Project AMOS (Acoustic, Meteorological, and Oceanographic Survey) (1 January 1953 - 31 December 1954), H. W. Marsh, Jr. and M. Schulkin, 21 March 1955.

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UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Naval Postgraduate School Monterey, California 93940	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE Temporal and Spacial Variability of Sound Propogation in the Ocean	
4. DESCRIPTIVE NOTES (Type of report and, inclusive dates) Master's Thesis; March 1971	
5. AUTHOR(S) (First name, middle initial, last name) Arthur D. Clark	

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1971	98	5

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Naval Postgraduate School Monterey, California 93940

13. ABSTRACT

The purpose of this study is to investigate the influence of non-environmental and small scale environmental acoustic factors on the variation of transmission loss within areas of the ocean which exhibit homogeniety of large scale environmental factors. The method employed was to identify the influencing and non-influencing factors, pool over the non-influencing factors if they existed, and investigate the nature and magnitude of the effect of the influencing factors on the variation of transmission loss.

The results generally indicated that source/receiver depth, the mixed layer, geographic location, and transmitting range and frequency significantly influenced the variation of transmission loss.

DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6811

UNCLASSIFIED

Security Classification

A-31408

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Acoustic						
Autocovariance						
Transmission						
Underwater						
Variation						

126364
Thesis
C4803
c.1
Clark
Temporal and spacial variability of sound propagation in the ocean.